Dark Matter Hierarchy and Hierarchy of EEGs

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Abstract

The model for EEG and ZEG follows neatly from the general model of high T_c superconductivity. A fractal hierarchy of EEGs and ZEGs is predicted labelled by p-adic length scales and an integer k_d characterizing the value of $\hbar$ at various levels of dark matter hierarchy. To make the representation self-contained this model is discussed in detail before proceeding to the models of EEG and ZEG.

1. General mechanisms of bio-superconductivity

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

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

Wormhole contacts can be interpreted as Higgs type fields and photon massivation could be understood in terms of a coherent state of charged wormhole contacts. The coherent states of charged wormhole contacts and of Cooper pairs do not imply non-conservation of energy, charge, and fermion number in zero energy ontology.

A crucial element is quantum criticality predicting a new kind of superconductivity explaining the strange features of high T_c super-conductivity. There are two kinds of Cooper pairs, exotic Cooper pairs and counterparts of ordinary BCS type Cooper pairs. Both correspond to a large value of Planck constant. Exotic Cooper pairs are quantum critical meaning that they can decay to ordinary electrons. Below temperature $T_{c_1} > T_c$ only exotic Cooper pairs with spin are present and their finite lifetime implies that super-conductivity is broken to ordinary conductivity satisfying scaling laws characteristic for criticality. At T_c spinless BCS type Cooper pairs become stable and exotic Cooper pairs can decay to them and vice versa. An open question is whether the BCS type Cooper pairs can be present also in the interior of cell.

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

Magnetic and Z^0 magnetic flux tubes and sheets are especially interesting candidates for supra current carries. In this case the Cooper pairs

must have spin one and this is indeed possible for exotic Cooper pairs. The fact that the critical magnetic (Z^0 magnetic) fields can be very weak or large values of $\hbar$ is in accordance with the idea that various almost topological quantum numbers characterizing induced magnetic fields provide a storage mechanism of bio-information.

This mechanism is extremely general and in principle works for electrons, protons, ions, charged molecules and even exotic neutrinos and an entire zoo of high T_c bio-superconductors, super-fluids and Bose-Einstein condensates is predicted. Of course, there are restrictions due to the thermal stability it room temperature and it seems that only electron, neutrino, and proton Cooper pairs are possible at room temperature besides Bose-Einstein condensates of all bosonic ions and their exotic counterparts resulting when some nuclear color bonds become charged.

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

The new model for the topological condensation at magnetic flux quanta of Earth's magnetic field is based on the dark matter hierarchy with levels characterized by the value of $\hbar(M_{\pm}^4, k_d) = \lambda^{k_d}\hbar_0$, $\lambda = 2^{11}$.

a) There are several levels of dynamics. In topological condensation the internal dynamics of ions is unaffected and $\hbar$ has the ordinary value. The formation of Cooper pairs involves dynamics at $k_d = 1$ level of dark matter hierarchy. Also the dynamics of ionic Cooper pairs remains unaffected in the topological condensation to magnetic flux quanta obeying $k_d > 1$ dynamics.

b) Cyclotron energies scale as as λ^{k_d} so that for a sufficiently high value of k thermal stability of cyclotron states at room temperature is achieved. Same applies to spin flip transitions in the recent scenario.

c) If the flux quanta of Earth's magnetic field correspond to $k_d = 4$ level of dark matter hierarchy, cyclotron energies $E = (\hbar/2\pi) \times ZeB/Am_p$ are scaled up by a factor $\lambda^4 \simeq 2^{44}$ from their ordinary values and are above thermal energy at room temperature for $A \leq 233Z$, where Z is the charge of the ion. Even for $Z = 1$ this includes all stable nuclei. Bose-Einstein condensates of bosonic ions are thus possible at room temperatures at Earth's surface. Cooper pairs of fermionic ions are possible only for $A \leq 4$ leaving in practice only protons into consideration. Also bosonic molecular ions can suffer BE condensation.

3. Fractal hierarchy of magnetic flux sheets

The notion of magnetic body is central in the TGD inspired theory of living matter. Every system possesses magnetic body and there are strong reasons to believe that the magnetic body associated with human body is of order Earth size and that there could be hierarchy of these bodies with even much larger sizes. Therefore the question arises what distinguishes between the magnetic bodies of Earth and human body. The quantization of magnetic flux suggests an answer to this question.

There are several manners to achieve quantization of magnetic flux with quantized value of effective Planck constant $\hbar_{eff}/\hbar_0 = \hbar(M_{\pm}^4)/\hbar(CP_2)$ appearing in Schrödinger equation. From the point of view of EEG and ZEG especially interesting are flux flux sheets which have thickness

$L(169)/\lambda = L(151) = 2.5$ nm carrying magnetic field having strength of Earth's magnetic field. These flux sheets have thickness of DNA double strand and total transversal length $L(169 + 5 \times 22) = L(257) = 1.6 \times 10^8$ km from flux quantization at $k_d = 4$ level of dark matter hierarchy necessary in order that the energies associated with cyclotron frequencies are above thermal threshold. Strongly folded flux sheets of this thickness might be associated with living matter and connect their DNAs to single coherent structure.

Suppose that the magnetic flux flows in head to tail direction so that the magnetic flux arrives to the human body through a layer of cortical neurons. Assume that the flux sheets traverse through the uppermost layer of neurons and also lower layers and that DNA of each neuronal nuclei define a transversal sections organized along flux sheet like text lines of a book page. The total length of DNA in single human cell is about one meter. It seem that single brain cannot provide the needed total length of DNA if DNA dominates the contribution: this if of course not at all necessarily. Even for $k_d < 4$ levels magnetic flux sheets could traverse nuclei belonging to different organisms.

This leads to the notion of super- and hyper genes. Super genes consist of genes in different cell nuclei arranged to threads along magnetic flux sheets like text lines on the page of book whereas hyper genes traverse through genomes of different organisms. Super and hyper genes provide an enormous representative capacity and together with the dark matter hierarchy allows to resolve the paradox created by the observation that human genome does not differ appreciably in size from that of wheat.

4. Fractal hierarchy of EEGs and ZEGs

There are three contributions to EEG besides neural noise: Schumann frequencies, cyclotron frequencies, and the frequencies associated with Josephson junctions determined by the sum of the constant voltage and voltage perturbation determined by the superposition of cyclotron frequencies. Cyclotron contribution can be interpreted as a control signal from a magnetic body in question labelled by k_d and affects both the ions at the flux sheets traversing DNA and the Josephson junction. The coherent state of photons generated by Josephson current corresponds to a reaction to this signal received by the magnetic body as a feedback. Schumann frequencies can be assigned to the control by magnetic body of Earth and correlate with the collective aspects of consciousness.

The analysis of the Josephson current leads to the conclusion that the frequencies in the coherent state of photons are in general sums and differences of Josephson frequency and harmonics of cyclotron frequencies. For small amplitudes this implies that alpha band to which the cyclotron frequencies most biologically important bosonic ions corresponds has as satellites theta and beta bands. Higher harmonics correspond to gamma and higher bands having also satellites. For large amplitudes EEG becomes chaotic which is indeed the property of beta band during say intense concentration or anxiety. The findings of Nunez about narrow 1-2 Hz wide bands at 3,5,7 Hz and 13,15,17 Hz confirm with the prediction of satellite bands and fix the Josephson frequency to 5 Hz. This picture explains the general characteristics of EEG in wake-up state qualitatively

and quantitatively.

In order to understand the characteristics during various stages of deep sleep one must assume that the cyclotron frequency scale of ions is scaled down by a factor of 1/2. One explanation is that right *resp.* left brain hemisphere corresponds to $Z = 2$ *resp.* $Z = 1$ quantization condition $Z \int BdS = n\hbar$ for the magnetic flux. $Z = 2$ case allows only doubly charged bosonic ions at magnetic flux sheets. $Z = 1$ case also also singly charged ions be their bosons or fermions and for this option magnetic field is scaled down by a factor of 1/2. The alternative explanation is that during sleep only Bose-Einstein condensates of singly charged exotic ions resulting when color bond inside nucleus becomes charged are present. This reduces the scale of cyclotron frequencies by a factor 1/2 and leaves only theta and delta bands. During stage 4 sleep only only DNA cyclotron frequencies in delta band are around 1 Hz and just above the thermal threshold are predicted to be present. For $k_d = 3$ and magnetic field scaled up by λ and flux tube area scaled down by λ^{-2} DNA frequencies are scaled up to kHz for $Z = 2$ flux quantization and might define neuronal synchronization frequencies.

The generalization of the model for EEG hierarchy to the case of ZEG is straightforward and cyclotron frequency spectrum is essentially the same. Z^0 ions are obtained when nuclear color bonds become charged and the combination of ordinary and exotic ionization can produce also em neutral Z^0 ions. Any atom, almost always boson, has an exotically charged counterpart with same statistics so that very rich spectrum of Bose-Einstein condensates results.

5. The effects of ELF em fields on brain

The experimental data about the effects of ELF em fields at cyclotron frequencies of various ions in Earth's magnetic field on vertebrate brains provide a test bench for the fractal hierarchy of EEGs. As a matter fact, it was the attempt to explain these effects, which eventually led to the discovery of the fractal hierarchy of EEGs and ZEGs.

The reported effects occur for harmonics of cyclotron frequencies of biologically important ions in Earth's magnetic field. They occur only in amplitude windows. The first one is around 10^{-7} V/m and second corresponds to the range $1 - 10$ V/m: the amplitudes of EEG waves are in the range 5-10 V/m. The effects are present only in the temperature interval 36-37 C.

The temperature interval has interpretation in terms of quantum criticality of high T_c superconductivity (both interior and boundary super currents are possible in this interval). Amplitude windows correspond to resonant EEG bands if the voltage perturbations contribute to the voltages over Josephson junctions and are thus coded to EEG. That the effects occur only for cyclotron frequencies and in the amplitude windows can be understood if there is AND gate involved. The voltage signal affects the interior of the cell nucleus opening communication line to the magnetic body if a harmonic of cyclotron frequency is in question. The signal affects also the Josephson junction which sends a signal to magnetic body if the voltage of the perturbation is large enough and corresponds to a frequency in the resonance band of EEG. The response of the magnetic

body affects nucleus only if the communication line is open. This AND gate eliminates very effectively the effects of neural noise.

6. EEG, ZEG, and consciousness

The interpretation of cyclotron phase transitions from the point of view of conscious experience is discussed. Cyclotron frequencies are ideal for communication, control, and coding purposes. One can also ask whether cyclotron transitions correspond to some sensory qualia. "General feeling of existence" possibly accompanying all sensory qualia is one possible identification for the quale involved. Also the possibility that cyclotron phase transitions could serve as quantum correlates for tastes and odors is discussed.

1 Introduction

The model for EEG and ZEG, as well as their variants with E in the middle replaced by K or something else, follows neatly from the general model of high T_c superconductivity [J1, J2]. A fractal hierarchy of EEGs and ZEGs is predicted labelled by p-adic length scales and an integer characterizing the value of $\hbar$ at various levels of dark matter hierarchy. To make the representation self-contained this model is discussed in detail before proceeding to the models of EEG and ZEG.

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The new model for the topological condensation at magnetic flux quanta of endogenous magnetic field $B = .2$ Gauss is based on the dark matter hierarchy with levels characterized by the value of $\hbar(k_d) = \lambda^{k_d}\hbar_0$, $\lambda = 2^{11}$.

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The experimental data about the effects of ELF em fields at cyclotron frequencies of various ions in endogenous magnetic field of .2 Gauss on vertebrate brains [90] provide a test bench for the fractal hierarchy of EEGs. As a matter fact, it was the attempt to explain these effects, which eventually led to the discovery of the fractal hierarchy of EEGs and ZEGs.

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1.6 TGD assigns 10 Hz biorhythm to electron as an intrinsic frequency scale

p-Adic coupling constant evolution and origins of p-adic length scale hypothesis have remained for a long time poorly understood. The progress made in the understanding of the S-matrix of the theory (or rather, its generalization M-matrix) [C2] has however changed the situation. The unexpected prediction is that zero energy ontology assigns to elementary particles macroscopic times scales. In particular, the time scale assignable to electron correspond to the fundamental biorhythm of 10 Hz.

1.6.1 M-matrix and coupling constant evolution

The final breakthrough in the understanding of p-adic coupling constant evolution came through the understanding of S-matrix, or actually M-matrix defining entanglement coefficients between positive and negative energy parts of zero energy states in zero energy ontology [C2]. M-matrix has interpretation as

a "complex square root" of density matrix and thus provides a unification of thermodynamics and quantum theory. S-matrix is analogous to the phase of Schrödinger amplitude multiplying positive and real square root of density matrix analogous to modulus of Schrödinger amplitude.

The notion of finite measurement resolution realized in terms of inclusions of von Neumann algebras allows to demonstrate that the irreducible components of M-matrix are unique and possesses huge symmetries in the sense that the hermitian elements of included factor $\mathcal{N} \subset \mathcal{M}$ defining the measurement resolution act as symmetries of M-matrix, which suggests a connection with integrable quantum field theories.

It is also possible to understand coupling constant evolution as a discretized evolution associated with time scales T_n, which come as octaves of a fundamental time scale: $T_n = 2^n T_0$. Number theoretic universality requires that renormalized coupling constants are rational or at most algebraic numbers and this is achieved by this discretization since the logarithms of discretized mass scale appearing in the expressions of renormalized coupling constants reduce to the form $log(2^n) = nlog(2)$ and with a proper choice of the coefficient of logarithm log(2) dependence disappears so that rational number results.

1.6.2 p-Adic coupling constant evolution

Could the time scale hierarchy $T_n = 2^n T_0$ defining hierarchy of measurement resolutions in time variable induce p-adic coupling constant evolution and explain why p-adic length scales correspond to $L_p \propto \sqrt{p}R$, $p \simeq 2^k$, R CP_2 length scale? This looks attractive but there is a problem. p-Adic length scales come as powers of $\sqrt{2}$ rather than 2 and the strongly favored values of k are primes and thus odd so that $n = k/2$ would be half odd integer. This problem can be solved.

1. The observation that the distance traveled by a Brownian particle during time t satisfies $r^2 = Dt$ suggests a solution to the problem. p-Adic thermodynamics applies because the partonic 3-surfaces X^2 are as 2-D dynamical systems random apart from light-likeness of their orbit. For CP_2 type vacuum extremals the situation reduces to that for a one-dimensional random light-like curve in M^4. The orbits of Brownian particle would now correspond to light-like geodesics γ_3 at X^3. The projection of γ_3 to a time=constant section $X^2 \subset X^3$ would define the 2-D path γ_2 of the Brownian particle. The M^4 distance r between the end points of γ_2 would be given $r^2 = Dt$. The favored values of t would correspond to $T_n = 2^n T_0$ (the full light-like geodesic). p-Adic length scales would result as $L^2(k) = DT(k) = D2^k T_0$ for $D = R^2/T_0$. Since only CP_2 scale is available as a fundamental scale, one would have $T_0 = R$ and $D = R$ and $L^2(k) = T(k)R$.

2. p-Adic primes near powers of 2 would be in preferred position. p-Adic time scale would not relate to the p-adic length scale via $T_p = L_p/c$ as assumed implicitly earlier but via $T_p = L_p^2/R_0 = \sqrt{p}L_p$, which corresponds

to secondary p-adic length scale. For instance, in the case of electron with $p = M_{127}$ one would have $T_{127} = .1$ second which defines a fundamental biological rhythm. Neutrinos with mass around .1 eV would correspond to $L(169) \simeq 5$ μm (size of a small cell) and $T(169) \simeq 1. \times 10^4$ years. A deep connection between elementary particle physics and biology becomes highly suggestive.

3. In the proposed picture the p-adic prime $p \simeq 2^k$ would characterize the thermodynamics of the random motion of light-like geodesics of X^3 so that p-adic prime p would indeed be an inherent property of X^3.

4. The fundamental role of 2-adicity suggests that the fundamental coupling constant evolution and p-adic mass calculations could be formulated also in terms of 2-adic thermodynamics. With a suitable definition of the canonical identification used to map 2-adic mass squared values to real numbers this is possible, and the differences between 2-adic and p-adic thermodynamics are extremely small for large values of for $p \simeq 2^k$. 2-adic temperature must be chosen to be $T_2 = 1/k$ whereas p-adic temperature is $T_p = 1$ for fermions. If the canonical identification is defined as

$$\sum_{n\geq 0} b_n 2^n \rightarrow \sum_{m\geq 1} 2^{-m+1} \sum_{(k-1)m\leq n<km} b_n 2^n \quad .$$

It maps all 2-adic integers $n < 2^k$ to themselves and the predictions are essentially same as for p-adic thermodynamics. For large values of $p \simeq 2^k$ 2-adic real thermodynamics with $T_R = 1/k$ gives essentially the same results as the 2-adic one in the lowest order so that the interpretation in terms of effective 2-adic/p-adic topology is possible.

1.6.3 p-Adic length scale hypothesis and biology

The basic implication of zero energy ontology is the formula $T(k) \simeq 2^{k/2} L(k)/c = L(2,k)/c$. This would be the analog of $E = hf$ in quantum mechanics and together hierarchy of Planck constants would imply direct connection between elementary particle physics and macroscopic physics. Especially important this connection would be in macroscopic quantum systems, say for Bose Einstein condensates of Cooper pairs, whose signature the rhythms with $T(k)$ as period would be. The presence of this kind of rhythms might even allow to deduce the existence of Bose-Einstein condensates of hitherto unknown particles.

1. For electron one has $T(k) = .1$ seconds which defines the fundamental $f_e = 10$ Hz bio-rhythm appearing as a peak frequency in alpha band. This could be seen as a direct evidence for a Bose-Einstein condensate of Cooper pairs of high T_c super-conductivity. That transition to "creative" states of mind involving transition to resonance in alpha band might be seen as evidence for formation of large BE condensates of electron Cooper pairs.

2. TGD based model for atomic nucleus [F9] predicts that nucleons are connected by flux tubes having at their ends light quarks and anti-quarks with masses not too far from electron mass. The corresponding p-adic frequencies $f_q = 2^k f_e$ could serve as a biological signature of exotic quarks connecting nucleons to nuclear strings . $k_q = 118$ suggested by nuclear string model would give $f_q = 2^{18} f_e = 26.2$ Hz. Schumann resonances are around 7.8, 14.3, 20.8, 27.3 and 33.8 Hz and f_q is not too far from 27.3 Hz Schumann resonance and the cyclotron frequency $f_c(^{11}B^+) = 27.3$ Hz for $B = .2$ Gauss explaining the effects of ELF em fields on vertebrate brain.

3. For a given $T(k)$ the harmonics of the fundamental frequency $f = 1/T(k)$ are predicted as special time scales. Also resonance like phenomena might present. In the case of cyclotron frequencies they would favor values of magnetic field for which the resonance condition is achieved. The magnetic field which in case of electron gives cyclotron frequency equal to 10 Hz is $B_e \simeq 3.03$ nT. For ion with charge Z and mass number A the magnetic field would be $B_I = \frac{A}{Z}(m_p/m_e)B_e$. The $B = .2$ Gauss magnetic field explaining the findings about effects of ELF em fields on vertebrate brain is near to B_I for ions with f_c alpha band. Hence the value of B could be understood in terms of resonance with electronic B-E condensate.

4. The hierarchy of Planck constants predicts additional time scales $T(k)$. The prediction depends on the strength of the additional assumptions made. One could have scales of form $nT(k)/m$ with m labeling the levels of hierarchy. $m = 1$ would give integers multiples of $T(k)$. Integers n could correspond to ruler and compass integers expressible as products of first powers of Fermat primes and power of 2. There are only four known Fermat primes so that one has $n = 2^n \prod_i F_i$, $F_i \in \{3, 5, 17, 257, 2^{16} + 1\}$. In the first approximation only 3- and 5- and 17-multiples of 2-adic length scales would result besides 2-adic length scales. In more general case products $m_1 m_2$ and ratios m_1/m_2 of ruler and compass integers and their inverses $1/m_1 m_2$ and $m_2 m_1$ are possible.

5. Mersenne primes are expected to define the most important fundamental p-adic time scales. The list of real and Gaussian (complex) Mersennes M_n possibly relevant for biology is given by n=89, 107, 113*, 127, 151*,157*, 163*, 167* ('*' tells that Gaussian Mersenne is in question).

n	89	107	113	127
f/Hz	2.7×10^{12}	1.0×10^7	1.6×10^5	10
n	151	157	163	167
T	19.4 d	3.40 y	218.0 y	3.49×10^3 y

(1)

1.7 DNA and topological quantum computation

The model of DNA as topological quantum computer led to a dramatic progress in the understanding of how magnetic body interacts with the biological body.

The model which looks the most plausible one relies on two specific ideas.

1. Sharing of labor means conjugate DNA would do tqc and DNA would "print" the outcome of tqc in terms of RNA yielding amino-acids in the case of exons. RNA could result in the case of introns. The experience about computers and the general vision provided by TGD suggests that introns could express the outcome of tqc also electromagnetically in terms of standardized field patterns. Also speech would be a form of gene expression. The quantum states braid would entangle with characteristic gene expressions.

2. The manipulation of braid strands transversal to DNA must take place at 2-D surface. The ends of the space-like braid are dancers whose dancing pattern defines the time-like braid, the running of classical tqc program. Space-like braid represents memory storage and tqc program is automatically written to memory during the tqc. The inner membrane of the nuclear envelope and cell membrane with entire endoplasmic reticulum included are good candidates for dancing halls. The 2-surfaces containing the ends of the hydrophobic ends of lipids could be the parquets and lipids the dancers. This picture seems to make sense.

One ends up to the model also in top-down manner.

1. Darwinian selection for which standard theory of self-organization provides a model, should apply also to tqc programs. Tqc programs should correspond to asymptotic self-organization patterns selected by dissipation in the presence of metabolic energy feed. The spatial and temporal pattern of the metabolic energy feed characterizes the tqc program - or equivalently - sub-program call.

2. Since braiding characterizes the tqc program, the self-organization pattern should correspond to a hydrodynamical flow or a pattern of magnetic field inducing the braiding. Braid strands must correspond to magnetic flux tubes of the magnetic body of DNA. If each nucleotide is transversal magnetic dipole it gives rise to transversal flux tubes, which can also connect to the genome of another cell.

3. The output of tqc sub-program is probability distribution for the outcomes of state function reduction so that the sub-program must be repeated very many times. It is represented as four-dimensional patterns for various rates (chemical rates, nerve pulse patterns, EEG power distributions,...) having also identification as temporal densities of zero energy states in various scales. By the fractality of TGD Universe there is a hierarchy of tqcs corresponding to p-adic and dark matter hierarchies. Programs (space-time sheets defining coherence regions) call programs in shorter scale. If the self-organizing system has a periodic behavior each tqc module defines a large number of almost copies of itself asymptotically. Generalized EEG could naturally define this periodic pattern and each period of EEG

would correspond to an initiation and halting of tqc. This brings in mind the periodically occurring sol-gel phase transition inside cell near the cell membrane.

4. Fluid flow must induce the braiding which requires that the ends of braid strands must be anchored to the fluid flow. Recalling that lipid monolayers of the cell membrane are liquid crystals and lipids of interior monolayer have hydrophilic ends pointing towards cell interior, it is easy to guess that DNA nucleotides are connected to lipids by magnetic flux tubes and hydrophilic lipid ends are stuck to the flow.

5. The topology of the braid traversing cell membrane cannot not affected by the hydrodynamical flow. Hence braid strands must be split during tqc. This also induces the desired magnetic isolation from the environment. Halting of tqc reconnects them and make possible the communication of the outcome of tqc.

6. There are several problems related to the details of the realization. How nucleotides A,T,C,G are coded to strand color and what this color corresponds to? The prediction that wormhole contacts carrying quark and anti-quark at their ends appear in all length scales in TGD Universe resolves the problem. How to split the braid strands in a controlled manner? High T_c super conductivity provides the mechanism: braid strand can be split only if the supra current flowing through it vanishes. A suitable voltage pulse induces the supra-current and its negative cancels it. The conformation of the lipid controls whether it it can follow the flow or not. How magnetic flux tubes can be cut without breaking the conservation of the magnetic flux? The notion of wormhole magnetic field saves the situation now: after the splitting the flux returns back along the second space-time sheet of wormhole magnetic field. The model inspires several testable hypothesis about DNA itself: in particular, the notion of anomalous em charge of DNA leads to several predictions of this kind. Also new mechanisms of catalytic action based on phase transitions reducing the value of Planck constant emerge.

1.8 EEG, ZEG, and consciousness

The interpretation of cyclotron phase transitions from the point of view of conscious experience is discussed. Cyclotron frequencies are ideal for communication, control, and coding purposes. One can also ask whether cyclotron transitions correspond to some sensory qualia. "General feeling of existence" possibly accompanying all sensory qualia is one possible identification for the quale involved. Also the possibility that cyclotron phase transitions could serve as quantum correlates for tastes and odors is discussed.

2 General TGD based view about super-conductivity

Today super-conductivity includes besides the traditional low temperature super-conductors many other non-orthodox ones [26]. These unorthodox super-conductors carry various attributes such cuprate, organic, dichalcogenide, heavy fermion, bismute oxide, ruthenate, antiferromagnetic and ferromagnetic. Mario Rabinowitz has proposed a simple phenomenological theory of superfluidity and super-conductivity which helps non-specialist to get a rough quantitative overall view about super-conductivity [26].

2.1 Basic phenomenology of super-conductivity

2.1.1 Basic phenomenology of super-conductivity

The transition to super-conductivity occurs at critical temperature T_c and involves a complete loss of electrical resistance. Super-conductors expel magnetic fields (Meissner effect) and when the external magnetic field exceeds a critical value H_c super-conductivity is lost either completely or partially. In the transition to super-conductivity specific heat has singularity. For long time magnetism and super-conductivity were regarded as mutually exclusive phenomena but the discovery of ferromagnetic super-conductors [28, 30] has demonstrated that reality is much more subtle.

The BCS theory developed by Bardeen, Cooper, and Schrieffer in 1957 provides a satisfactory model for low T_c super-conductivity in terms of Cooper pairs. The interactions of electrons with the crystal lattice induce electron-electron interaction binding electrons to Cooper pairs at sufficiently low temperatures. The electrons of Cooper pair are at the top of Fermi sphere (otherwise they cannot interact to form bound states) and have opposite center of mass momenta and spins. The binding creates energy gap E_{gap} determining the critical temperature T_c. The singularity of the specific heat in the transition to super-conductivity can be understood as being due to the loss of thermally excitable degrees of freedom at critical temperature so that heat capacity is reduced exponentially. BCS theory has been successful in explaining the properties of low temperature super conductors but the high temperature super-conductors discovered in 1986 and other non-orthodox superconductors discovered later remain a challenge for theorists.

The reasons why magnetic fields tend to destroy super-conductivity is easy to understand. Lorentz force induces opposite forces to the electrons of Cooper pair since the momenta are opposite. Magnetic field tends also to turn the spins in the same direction. The super-conductivity is destroyed in fields for which the interaction energy of magnetic moment of electron with field is of the same order of magnitude as gap energy $E_{gap} \sim T_c$: $e\hbar H_c/2m \sim T_c$.

If spins are parallel, the situation changes since only Lorentz force tends to destroy the Cooper pair. In high T_c super-conductors this is indeed the case: electrons are in spin triplet state ($S = 1$) and the net orbital angular momentum of Cooper pair is $L = 2$. The fact that orbital state is not $L = 0$

state makes high T_c super-conductors much more fragile to the destructive effect of impurities than conventional super-conductors (due to the magnetic exchange force between electrons responsible for magnetism). Also the Cooper pairs of ^3He superfluid are in spin triplet state but have $S = 0$.

The observation that spin triplet Cooper pairs might be possible in ferromagnets stimulates the question whether ferromagnetism and super-conductivity might tolerate each other after all, and the answer is affirmative [30]. The article [28] provides an enjoyable summary of experimental discoveries.

2.1.2 Basic parameters of super-conductors from universality?

Super conductors are characterized by certain basic parameters such as critical temperature T_c and critical magnetic field H_c, densities n_c and n of Cooper pairs and conduction electrons, gap energy E_{gap}, correlation length ξ and magnetic penetration length λ. The super-conductors are highly complex systems and calculation of these parameters from BCS theory is either difficult or impossible.

It has been suggested [26] that these parameters might be more or less universal so that they would not depend on the specific properties of the interaction responsible for the formation of Cooper pairs. The motivation comes from the fact that the properties of ordinary Bose-Einstein condensates do not depend on the details of interactions. This raises the hope that these parameters might be expressible in terms of some basic parameters such as T_c and the density of conduction electrons allowing to deduce Fermi energy E_F and Fermi momentum k_F if Fermi surface is sphere. In [26] formulas for the basic parameters are indeed suggested based on this of argumentation assuming that Cooper pairs form a Bose-Einstein condensate.

1. The most important parameters are critical temperature T_c and critical magnetic field H_c in principle expressible in terms of gap energy. In [26] the expression for T_c is deduced from the condition that the de Broglie wavelength λ must satisfy in supra phase the condition

$$\lambda \geq 2d = 2(\frac{n_c}{g})^{-1/D} \tag{2}$$

guaranteing the quantum overlap of Cooper pairs. Here n_c is the density of Bose-Einstein condensate of Cooper pairs and g is the number of spin states and D the dimension of the condensate. This condition follows also from the requirement that the number of particles per energy level is larger than one (Bose-Einstein condensation).

Identifying this expression with the de Broglie wavelength $\lambda = \hbar/\sqrt{2mE}$ at thermal energy $E = (D/2)T_c$, where D is the number of degrees of freedom, one obtains

$$T_c \leq \frac{h^2}{4Dm}(\frac{n_c}{g})^{2/D} \quad . \tag{3}$$

m denotes the effective mass of super current carrier and for electron it can be even 100 times the bare mass of electron. The reason is that the electron moves is somewhat like a person trying to move in a dense crowd of people, and is accompanied by a cloud of charge carriers increasing its effective inertia. In this equation one can consider the possibility that Planck constant is not the ordinary one. This obviously increases the critical temperature unless n_c is scaled down in same proportion in the phase transition to large $\hbar$ phase.

2. The density of n_c Cooper pairs can be estimated as the number of fermions in Fermi shell at E_F having width Δk deducible from kT_c. For $D = 3$-dimensional spherical Fermi surface one has

$$\begin{aligned} n_c &= \frac{1}{2}\frac{4\pi k_F^2 \Delta k}{\frac{4}{3}\pi k_F^3} n \ , \\ kT_c &= E_F - E(k_F - \Delta k) \simeq \frac{h^2 k_F \Delta k}{m} \ . \end{aligned} \tag{4}$$

Analogous expressions can be deduced in $D = 2$- and $D = 1$-dimensional cases and one has

$$n_c(D) = \frac{D}{2}\frac{T_c}{E_F} n(D) \ . \tag{5}$$

The dimensionless coefficient is expressible solely in terms of n and effective mass m. In [26] it is demonstrated that the inequality 3 replaced with equality when combined with 5 gives a satisfactory fit for 16 superconductors used as a sample.

Note that the Planck constant appearing in E_F and T_c in Eq. 5 must correspond to ordinary Planck constant $\hbar_0$. This implies that equations 3 and 5 are consistent within orders of magnitudes. For $D = 2$, which corresponds to high T_c superconductivity, the substitution of n_c from Eq. 5 to Eq. 3 gives a consistency condition from which n_c disappears completely. The condition reads as

$$n\lambda_F^2 = \pi = 4g \ .$$

Obviously the equation is not completely consistent.

3. The magnetic penetration length λ is expressible in terms of density n_c of Cooper pairs as

$$\lambda^{-2} = \frac{4\pi e^2 n_c}{m_e} \ . \tag{6}$$

The ratio $\kappa \equiv \frac{\lambda}{\xi}$ determines the type of the super conductor. For $\kappa < \frac{1}{\sqrt{2}}$ one has type I super conductor with defects having negative surface energy. For $\kappa \geq \frac{1}{\sqrt{2}}$ one has type II super conductor and defects have positive surface energy. Super-conductors of type I this results in complex stripe like flux patterns maximizing their area near criticality. The super-conductors of type II have $\kappa > 1/\sqrt{2}$ and the surface energy is positive so that the flux penetrates as flux quanta minimizing their area at lower critical value H_{c_1} of magnetic field and completely at higher critical value H_{c_2} of magnetic field. The flux quanta contain a core of size ξ carrying quantized magnetic flux.

4. Quantum coherence length ξ can be roughly interpreted as the size of the Cooper pair or as the size of the region where it is sensible to speak about the phase of wave function of Cooper pair. For larger separations the phases of wave functions are un-correlated. The values of ξ vary in the range $10^3 - 10^4$ Angstrom for low T_c super-conductors and in the range $5 - 20$ Angstrom for high T_c super-conductors (assuming that they correspond to ordinary $\hbar$!) the ratio of these coherence lengths varies in the range $[50-2000]$, with upper bound corresponding to $n_F = 2^{11}$ for $\hbar$. This would give range $1-2$ microns for the coherence lengths of high T_c super-conductors with lowest values of coherence lengths corresponding to the highest values of coherence lengths for low temperatures super conductors.

Uncertainty Principle $\delta E \delta t = \hbar/2$ using $\delta E = E_{gap} \equiv 2\Delta$, $\delta t = \xi/v_F$, gives an order of magnitude estimate for ξ differing only by a numerical factor from the result of a rigorous calculation given by

$$\xi = \frac{4\hbar v_F}{E_{gap}} \ . \tag{7}$$

E_{gap} is apart from a numerical constant equal to T_c: $E_{gap} = nT_c$. Using the expression for v_F and T_c in terms of the density of electrons, one can express also ξ in terms of density of electrons.

For instance, BCS theory predicts $n = 3.52$ for metallic super-conductors and $n = 8$ holds true for cuprates [26]. For cuprates one obtains $\xi = 2n^{-1/3}$ [26]. This expression can be criticized since cuprates are Mott insulators and it is not at all clear whether a description as Fermi gas makes sense. The fact that high T_c super-conductivity involves breakdown of anti-ferromagnetic order might justify the use of Fermi gas description for conducting holes resulting in the doping.

For large $\hbar$ the value of ξ would scale up dramatically if deduced theoretically from experimental data using this kind of expression. If the estimates for ξ are deduced from v_F and T_c purely calculationally as seems to be the case, the actual coherence lengths would be scaled up by a factor $\hbar/\hbar_0 = n_F$ if high T_c super-conductors correspond to large $\hbar$ phase. As also found that this would also allow to understand the high critical temperature.

2.2 Universality of parameters in TGD framework

Universality idea conforms with quantum criticality of TGD Universe. The possibility to express everything in terms of density of critical temperature coding for the dynamics of Cooper pair formation and the density charge carriers would make it also easy to understand how p-adic scalings and transitions to large $\hbar$ phase affect the basic parameters. The possible problem is that the replacement of inequality of Eq. 3 with equality need not be sensible for large $\hbar$ phases. It will be found that in many-sheeted space-time T_c does not directly correspond to the gap energy and the universality of critical temperature follows from the p-adic length scale hypothesis.

2.2.1 The effective of p-adic scaling on the parameters of superconductors

1. The behavior of the basic parameters under p-adic scaling and scaling of Planck constant

p-Adic fractality expresses as $n \propto 1/L^3(k)$ would allow to deduce the behavior of the various parameters as function of the p-adic length scale and naive scaling laws would result. For instance, E_{gap} and T_c would scale as $1/L^2(k)$ if one assumes that the density n of particles at larger space-time sheets scales p-adically as $1/L^3(k)$. The basic implication would be that the density of Cooper pairs and thus also T_c would be reduced very rapidly as a function of the p-adic length scale. Without thermal isolation between these space-time sheets and hight temperature space-time sheets there would not be much hopes about high T_c super-conductivity.

In the scaling of Planck constant basic length scales scale up and the overlap criterion for super-conductivity becomes easy to satisfy unless the density of electrons is reduced too dramatically. As found, also the critical temperature scales up so that there are excellent hopes of obtain high T_c super-conductor in this manner. The claimed short correlation lengths are not a problem since they are calculational quantities. As a matter fact, the

2. Could gap energies be universal?

Suppose that the super-conducting electrons are at a space-time sheet corresponding to some p-adic length scale. They can leak to either larger or smaller space-time sheets via the formation of join along boundaries bonds. The energy E_J associated with the formation of a join along boundaries bond connecting two space-time sheets characterized by k_1 and k_2 mediating transfer of Cooper pair to smaller space-time sheet defines a potential barrier so that for thermal energies below this energy no join along boundaries bonds are formed to smaller space-time sheets. The gap energy deduced from T_c would not necessarily correspond in this case to the binding energy of Cooper pair but to the energy $E_J > E_{gap}$ of the join along boundaries bond.

One can imagine two options for E_J in the approximation that the interac-

tion energy of Cooper pair with surroundings is neglected.

Option I: The formation of JAB is a process completely independent from the flow of Cooper pair through it and thermal photons are responsible for it. In this case the order of magnitude for E_J would naturally correspond to $\hbar/L(k_1)$. Cell size $L(167) = 2.5$ μm would correspond to $E_J \sim .4$ eV which does not make sense.

Option II: One cannot separate the flow of the Cooper pair through the JAB from its formation involving the localization to smaller space-time sheet requiring thermal photon to provide the difference of zero point kinetic energies. E_J would naturally correspond to the difference $\Delta E_0 = E_0(k_1) - E_0(k_2)$ of zero point kinetic energies $E_0(k) = D\pi^2\hbar^2/4mL^2(k)$ of the Cooper pair, where D is the effective dimensionality of the sheets. The reason why JABs inducing the flow $k_1 \to k_2$ of charge carriers are not formed spontaneously must be that charge carriers at k_1 space-time sheet are in a potential well. This option seems to work although it is certainly oversimplified since it neglects the interaction energy of Cooper pairs with other particles and wormhole throats behaving effectively like particles.

If E_J given as difference of zero point kinetic energies, determines the critical temperature rather than E_{gap}, universality of the critical temperature as a difference of zero point kinetic energies is predicted. In this kind of situation the mechanism binding electrons to Cooper pairs is not relevant for what is observed as long as it produces binding energy and energy gap between ground state and first excited state larger than the thermal energy at the space-time sheet in question. This temperature is expected to scale as zero point kinetic energy. As already found, the work of Rabinowitz [26] seems to support this kind of scaling law.

3. Critical temperatures for low and high T_c super conductors

Consider now critical temperatures for low and high T_c electronic superconductors for option II assuming $D = 3$.

1. For low T_c super conductors and for the transition $k_2 = 167 \to k_1 = 163$ this would give $\Delta E_0 = E_0(163) \sim 6 \times 10^{-6}$ eV, which corresponds to $T_c \sim .06$ K. For $k_2 = 163 \to 157$ this would give $\Delta E \sim 1.9 \times 10^{-4}$ eV corresponding to 1.9 K. These orders of magnitude look rather reasonable since the coherence length ξ expected to satisfy $\xi \leq L(k_2)$, varies in the range $.1 - 1$ μm for low T_c super conductors.

2. For high T_c super-conductors with ξ in the range $5 - 20$ Angstrom, $E_J \sim 10^{-2}$ eV would give $k_1 = 149$, which would suggest that high T_c superconductors correspond to $k = 151$ and $\xi \ll L(k_2 = 151) = 10$ nm (cell membrane thickness). In this case $\Delta << E_J$ is quite possible so that high T_c super-conductivity would be due to thermal isolation rather than a large value of energy gap. This provides a considerable flexibility concerning the modelling of mechanisms of Cooper pair formation.

4. $E_J < E_{gap}$ case as a transition to partial super-conductivity

For $E_J < E_{gap}$ the transition at $T_c \simeq E_J$ does not imply complete loss of resistivity since the Cooper pairs can flow to smaller space-time sheets and back without being destroyed and this is expected to induce dissipative effects. Some super-conductors such as $ZrZn_2$ ferromagnet do not lose their resistivity completely and the anomaly of specific heat is absent [28]. The mundane explanation is that super-conductivity exists only in clusters.

2.2.2 The effect of the scaling of $\hbar$ to the parameters of BCS superconductor

It is of interest to study the behavior of the various parameters in the transition to the possibly existing large $\hbar$ variant of super-conducting electrons. Also small scalings of $\hbar$ are possible and the considerations to follow generalize trivially to this case. Under what conditions the behavior of the various parameters in the transition to large $\hbar$ phase is dictated by simple scaling laws?

1. Scaling of T_c and E_{gap}

T_c and E_{gap} remain invariant if E_{gap} corresponds to a purely classical interaction energy remaining invariant under the scaling of $\hbar$. This is not the case for BCS super-conductors for which the gap energy Δ has the following expression.

$$\begin{aligned} \Delta &= \hbar\omega_c exp(-1/X) \ , \\ X &= n(E_F)U_0 = \frac{3}{2}N(E_F)\frac{U_0}{E_F} \ , \\ n(E_F) &= \frac{3}{2}\frac{N(E_F)}{E_F} \ . \\ \omega_c &= \omega_D = (6\pi^2)^{1/3} c_s n_n^{1/3} \ . \end{aligned} \tag{8}$$

Here ω_c is the width of energy region near E_F for which "phonon" exchange interaction is effective. n_n denotes the density of nuclei and c_s denotes sound velocity.

$N(E_F)$ is the total number of electrons at the super-conducting space-time sheet. U_0 would be the parameter characterizing the interaction strength of of electrons of Cooper pair and should not depend on $\hbar$. For a structure of size $L \sim 1$ μ m one would have $X \sim n_a 10^{12} \frac{U_0}{E_F}$, n_a being the number of exotic electrons per atom, so that rather weak interaction energy U_0 can give rise to $\Delta \sim \omega_c$.

The expression of ω_c reduces to Debye frequency ω_D in BCS theory of ordinary super conductivity. If c_s is proportional to thermal velocity $\sqrt{T_c/m}$ at criticality and if n_n remains invariant in the scaling of $\hbar$, Debye energy scales up as $\hbar$. This can imply that $\Delta > E_F$ condition making scaling non-sensible unless one has $\Delta \ll E_F$ holding true for low T_c super-conductors. This kind of situation would *not* require large $\hbar$ phase for electrons. What would be needed that nuclei and phonon space-time sheets correspond to large $\hbar$ phase.

What one can hope is that Δ scales as $\hbar$ so that high T_c superconductor would result and the scaled up T_c would be above room temperature for $T_c > .15$ K. If electron is in ordinary phase X is automatically invariant in the scaling of $\hbar$. If not, the invariance reduces to the invariance of U_0 and E_F under the scaling of $\hbar$. If n scales like $1/\hbar^D$, E_F and thus X remain invariant. U_0 as a simplified parametrization for the interaction potential expressible as a tree level Feynman diagram is expected to be in a good approximation independent of $\hbar$.

It will be found that high in high T_c super-conductors, which seem to be quantum critical, a high T_c variant of phonon mediated superconductivity and exotic superconductivity could be competing. This would suggest that the phonon mediated superconductivity corresponds to a large $\hbar$ phase for nuclei scaling ω_D and T_c by a factor $\simeq 2^{11}$.

Since the total number $N(E_F)$ of electrons at larger space-time sheet behaves as $N(E_F) \propto E_F^{D/2}$, where D is the effective dimension of the system, the quantity $1/X \propto E_F/n(E_F)$ appearing in the expressions of the gap energy behaves as $1/X \propto E_F^{-D/2+1}$. This means that at the limit of vanishing electron density $D = 3$ gap energy goes exponentially to zero, for $D = 2$ it is constant, and for $D = 1$ it goes zero at the limit of small electron number so that the formula for gap energy reduces to $\Delta \simeq \omega_c$. These observations suggests that the super-conductivity in question should be 2- or 1-dimensional phenomenon as in case of magnetic walls and flux tubes.

2. Scaling of ξ and λ

If n_c for high T_c super-conductor scales as $1/\hbar^D$ one would have $\lambda \propto \hbar^{D/2}$. High T_c property however suggests that the scaling is weaker. ξ would scale as $\hbar$ for given v_F and T_c. For $D = 2$ case the this would suggest that high T_c super-conductors are of type I rather than type II as they would be for ordinary $\hbar$. This conforms with the quantum criticality which would be counterpart of critical behavior of super-conductors of type I in nearly critical magnetic field.

3. Scaling of H_c and B

The critical magnetization is given by

$$H_c(T) \quad = \quad \frac{\Phi_0}{\sqrt{8}\pi\xi(T)\lambda(T)} \tag{9}$$

where Φ_0 is the flux quantum of magnetic field proportional to $\hbar$. For $D = 2$ and $n_c \propto \hbar^{-2}$ $H_c(T)$ would not depend on the value of $\hbar$. For the more physical dependence $n_c \propto \hbar^{-2+\epsilon}$ one would have $H_c(T) \propto \hbar^{-\epsilon}$. Hence the strength of the critical magnetization would be reduced by a factor $2^{-11\epsilon}$ in the transition to the large $\hbar$ phase with $n_F = 2^{-11}$.

Magnetic flux quantization condition is replaced by

$$\int 2eBdS = n\hbar 2\pi \ . \tag{10}$$

B denotes the magnetic field inside super-conductor different from its value outside the super-conductor. By the quantization of flux for the non-super-conducting core of radius ξ in the case of super-conductors of type II $eB = \hbar/\xi^2$ holds true so that B would become very strong since the thickness of flux tube would remain unchanged in the scaling.

2.3 Quantum criticality and super-conductivity

The notion of quantum criticality has been already discussed in introduction. An interesting prediction of the quantum criticality of entire Universe also gives naturally rise to a hierarchy of macroscopic quantum phases since the quantum fluctuations at criticality at a given level can give rise to higher level macroscopic quantum phases at the next level. A metaphor for this is a fractal cusp catastrophe for which the lines corresponding to the boundaries of cusp region reveal new cusp catastrophes corresponding to quantum critical systems characterized by an increasing length scale of quantum fluctuations.

Dark matter hierarchy could correspond to this kind of hierarchy of phases and long ranged quantum slow fluctuations would correspond to space-time sheets with increasing values of $\hbar$ and size. Evolution as the emergence of modules from which higher structures serving as modules at the next level would correspond to this hierarchy. Mandelbrot fractal with inversion analogous to a transformation permuting the interior and exterior of sphere with zooming revealing new worlds in Mandelbrot fractal replaced with its inverse would be a good metaphor for what quantum criticality would mean in TGD framework.

2.3.1 How the quantum criticality of superconductors relates to TGD quantum criticality

There is empirical support that super-conductivity in high T_c super-conductors and ferromagnetic systems [28, 29] is made possible by quantum criticality [27]. In the experimental situation quantum criticality means that at sufficiently low temperatures quantum rather than thermal fluctuations are able to induce phase transitions. Quantum criticality manifests itself as fractality and simple scaling laws for various physical observables like resistance in a finite temperature range and also above the critical temperature. This distinguishes sharply between quantum critical super conductivity from BCS type super-conductivity. Quantum critical super-conductivity also exists in a finite temperature range and involves the competition between two phases.

The absolute quantum criticality of the TGD Universe maps to the quantum criticality of subsystems, which is broken by finite temperature effects bringing dissipation and freezing of quantum fluctuations above length and time scales determined by the temperature so that scaling laws hold true only in a finite temperature range.

Reader has probably already asked what quantum criticality precisely means. What are the phases which compete? An interesting hypothesis is that quantum criticality actually corresponds to criticality with respect to the phase transition

changing the value of Planck constant so that the competing phases would correspond to different values of $\hbar$. This hypothesis seems to work in the case of high T_c super-conductivity. The prediction is that quantum criticality sets on at some critical temperature $T_{c_1} > T_c$ meaning the emergence of exotic Cooper pairs which are however unstable against decay to ordinary electrons so that the super-conductivity in question gives rise to ordinary conductivity in time scales longer than the lifetime of exotic Cooper pair dictated by temperature. These exotic Cooper pairs can also transform to BCS type Cooper pairs which are stable below T_c.

2.3.2 Scaling up of de Broglie wave lengths and criterion for quantum overlap

Compton lengths and de Broglie wavelengths are scaled up by an integer n, whose preferred values correspond to $n_F = 2^k \prod_s F_s$, where $F_s = 2^{2^s} + 1$ are distinct Fermat primes. In particular, $n_F = 2^{k11}$ seem to be favored. The scaling up means that the overlap condition $\lambda \geq 2d$ for the formation of Bose-Einstein condensate can be satisfied and the formation of Cooper pairs becomes possible. Thus a hierarchy of large $\hbar$ super-conductivities would be associated with to the dark variants of ordinary particles having essentially same masses as the ordinary particles.

Unless one assumes fractionization, the invariance of $E_F \propto \hbar_{eff}^2 n^{2/3}$ in $\hbar$ increasing transition would require that the density of Cooper pairs in large $\hbar$ phase is scaled down by an appropriate factor. This means that supra current intensities, which are certainly measurable quantities, are also scaled down. Of course, it could happen that E_F is scaled up and this would conform with the scaling of the gap energy.

2.3.3 Possible implications of charge and spin fractionization

Masses as given by representations of super conformal algebras and p-adic thermodynamics are invariant under changes of the Planck constants. The original assumption that Poincare quantum numbers are invariant in Planck constant changing quantum transition is however too strong and conflicts with the model explaining quantization of planetary orbits in terms of gigantic value of $\hbar_{eff}$ [D6, J6]. What happens is spin fractionization with unit of spin replaced with n_a/n_b and fractionization of color and presumably of also electro-weak charges with unit given by n_b/n_a. For instance, n_a/n_b fractionization would happen for angular momentum quantum number m, for the integer n characterizing the Bohr orbits of atom, harmonic oscillator, and integers labelling the states of particle in box.

The fractionization can be understood in terms of multiple covering of M^4 by symmetry related CP_2 points formed in the phase transition increasing $\hbar$ [C7]. The covering is characterized by $G_b \subset SU(2) \subset SU(3)$ and fixed points correspond to orbifold points. The copies of imbedding space with different G are glued with each other along M^4 factors at orbifold point, representing origin

of CP_2.

An interesting implication of spin fractionization is that for n_a and $n_b = 1$ the unit of spin would become n_a standard units. This might be interpreted by saying that minimum size of a Bose Einstein condensate consisting of spin 1 Cooper pairs is $n_b/2$ Cooper pairs with spin 1. On the other hand charge could be fractionized to e/n_b in this case. A possible interpretation is that electron is delocalized to n_a separate G_a related sheets of the M^4 covering of CP_2 projection such that each of them carries a fractional charge e/n_a. Geometrically this would correspond to a ring consisting of n_a discrete points.

2.3.4 Quantum critical super-conductors in TGD framework

For quantum critical super-conductivity in heavy fermions systems, a small variation of pressure near quantum criticality can destroy ferromagnetic (anti-ferromagnetic) order so that Curie (Neel) temperature goes to zero. The prevailing spin fluctuation theory [31] assumes that these transitions are induced by long ranged and slow spin fluctuations at critical pressure P_c. These fluctuations make and break Cooper pairs so that the idea of super-conductivity restricted around critical point is indeed conceivable.

Heavy fermion systems, such as cerium-indium alloy $CeIn_3$ are very sensitive to pressures and a tiny variation of density can drastically modify the low temperature properties of the systems. Also other systems of this kind, such as $CeCu_2Ge_2$, $CeIn_3$, $CePd_2Si_2$ are known [28, 30]. In these cases super-conductivity appears around anti-ferromagnetic quantum critical point.

The last experimental breakthrough in quantum critical super-conductivity was made in Grenoble [29]. URhGe alloy becomes super-conducting at $T_c = .280$ K, loses its super-conductivity at $H_c = 2$ Tesla, and becomes again super-conducting at $H_c = 12$ Tesla and loses its super-conductivity again at $H = 13$ Tesla. The interpretation is in terms of a phase transition changing the magnetic order inducing the long range spin fluctuations.

TGD based models of atomic nucleus [F8] and condensed matter [F10] assume that weak gauge bosons with Compton length of order atomic radius play an essential role in the nuclear and condensed matter physics. The assumption that condensed matter nuclei possess anomalous weak charges explains the repulsive core of potential in van der Waals equation and the very low compressibility of condensed matter phase as well as various anomalous properties of water phase, provide a mechanism of cold fusion and sono-fusion, etc. [F10, J6]. The pressure sensitivity of these systems would directly reflect the physics of exotic quarks and electro-weak gauge bosons. A possible mechanism behind the phase transition to super-conductivity could be the scaling up of the sizes of the space-time sheets of nuclei.

Also the electrons of Cooper pair (and only these) could make a transition to large $\hbar$ phase. This transition would induce quantum overlap having geometric overlap as a space-time correlate. The formation of join along boundaries bonds between neighboring atoms would be part of the mechanism. For instance, the criticality condition $4n^2\alpha = 1$ for BE condensate of n Cooper pairs would

give $n = 6$ for the size of a higher level quantum unit possibly formed formed from Cooper pairs. If one does not assume invariance of energies obtained by fractionization of principal quantum number, this transition has dramatic effects on the spectrum of atomic binding energies scaling as $1/\hbar^2$ and practically universal spectrum of atomic energies would result [J6] not depending much on nuclear charge. It seems that this prediction is non-physical.

Quantum critical super-conductors resemble superconductors of type I with $\lambda \ll \xi$ for which defects near thermodynamical criticality are complex structures looking locally like stripes of thickness λ. These structure are however dynamical in super-conducting phase. Quite generally, long range quantum fluctuations due to the presence of two competing phases would manifest as complex dynamical structures consisting of stripes and their boundaries. These patterns are dynamical rather than static as in the case of ordinary spin glass phase so that quantum spin glass or 4-D spin glass is a more appropriate term.

The breaking of classical non-determinism for vacuum extremals indeed makes possible space-time correlates for quantum non-determinism and this makes TGD Universe a 4-dimensional quantum spin glass. The model for high T_c super-conductors leads to the conclusion that the boundaries between the two phases are the carriers of the supra currents. Wormhole contacts appear naturally at boundaries and the mere assumption that $q\bar{q}$ type wormhole contacts feed the em gauge flux of electrons from the space-time sheet of Cooper pair to a larger space-time sheet predicts correctly the properties of high T_c Cooper pairs.

2.3.5 Could quantum criticality make possible new kinds of high T_c super-conductors?

The transition to large $\hbar$ phase increases various length scales by n/v_0 and makes possible long range correlations even at high temperatures. Hence the question is whether large $\hbar$ phase could correspond to ordinary high T_c super-conductivity. If this were the case in the case of ordinary high T_c super-conductors, the actual value of coherence length ξ would vary in the range $5 - 20$ Angstrom scaled up by a factor n/v_0 to $n - 40n$ μm to be compared with the range $.2 - 2$ μm for low T_c super-conductors. The density of Cooper pairs would be scaled down by an immensely small factor $2^{-33}/n^3$ from its value deduced from Fermi energy so that neither high T_c nor ordinary super-conductors can correspond to larger $\hbar$ phase for electrons.

Large $\hbar$ phase for some nuclei might be involved and make possible large space-time sheets of size at least of order of ξ at which conduction electrons forming Cooper pairs would topologically condense like quarks around hadronic space-time sheets (in [F10] a model of water as a partially dark matter with one fourth of hydrogen ions in large $\hbar$ phase is developed).

Consider for a moment the science fictive possibility that super conducting electrons for some quantum critical super-conductors to be discovered or already discovered correspond to large $\hbar$ phase with $\hbar(k) = n_F\hbar_0$ keeping in mind that this affects only quantum corrections in perturbative approach but not the

lowest order classical predictions of quantum theory. For $n_F = n/v_0 \simeq n2^{k11}$ with $k = 1, n = 1$ the size of magnetic body would be $L(149) = 5$ nm, the thickness of the lipid layer of cell membrane. For $k = 2, n = 1$ the size would be $L(171) = 10$ μm, cell size. If the density of Cooper pairs is of same order of magnitude as in case of ordinary super conductors, the critical temperature is scaled up by 2^{k11}. Already for $k = 1$ the critical temperature of 1 K would be scaled up to $4n^2 \times 10^6$ K if n_c is not changed. This assumption is not consistent with the assumption that Fermi energy remains non-relativistic. For $n = 1$ $T_c = 400$ K would be achieved for $n_c \to 10^{-6} n_c$, which looks rather reasonable since Fermi energy transforms as $E_F \to 8 \times 10^3 E_F$ and remains non-relativistic. H_c would scale down as $1/\hbar$ and for $H_c = .1$ Tesla the scaled down critical field would be $H_c = .5 \times 10^{-4}$ Tesla, which corresponds to the nominal value of the Earth's magnetic field.

Quantum critical super-conductors become especially interesting if one accepts the identification of living matter as ordinary matter quantum controlled by macroscopically quantum coherent dark matter. One of the basic hypothesis of TGD inspired theory of living matter is that the magnetic flux tubes of the Earth's magnetic field carry a super-conducting phase and the spin triplet Cooper pairs of electrons in large $\hbar$ phase might realize this dream. That the value of Earth's magnetic field is near to its critical value could have also biological implications.

2.4 Space-time description of the mechanisms of superconductivity

The application of ideas about dark matter to nuclear physics and condensed matter suggests that dark color and weak forces should be an essential element of chemistry and condensed matter physics. The continual discovery of new superconductors, in particular of quantum critical superconductors, suggests that super-conductivity is not well understood. Hence super-conductivity provides an obvious test for these ideas. In particular, the idea that wormhole contacts regarded as parton pairs living at two space-time sheets simultaneously, provides an attractive universal mechanism for the formation of Cooper pairs and is not so far-fetched as it might sound first.

2.4.1 Leading questions

It is good to begin with a series of leading questions.

1. The work of Rabinowitch [26] suggests that that the basic parameters of super-conductors might be rather universal and depend on T_c and conduction electron density only and be to a high degree independent of the mechanism of super-conductivity. This is in a sharp contrast to the complexity of even BCS model with its somewhat misty description of the phonon exchange mechanism.
   Questions: Could this mean that there exists a simple universal description

of various kinds of super-conductivities? Could this mechanism involve large $\hbar$ phase for nuclei in case of quantum critical super-conductivity? Could wormhole contacts or their Bose-Einstein condensate play some role. Are the Cooper pairs of quantum critical super-conductors at the boundaries of the competing phases?

2. The effective masses of electrons in ferromagnetic super-conductors are in the range of 10-100 electron masses [28] and this forces to question the idea that ordinary Cooper pairs are current carriers. Quantum classical correspondence requires that bound states involve formation of join along boundaries bonds between bound particles. In the case of Cooper pairs in ordinary superconductors the length of join along boundaries bonds between electrons should be of order $10^3 - 10^4$ Angstroms. This looks rather strange.

   Questions: Could quantum classical correspondence help to identify the mechanism giving rise to Cooper pairs? The simplest model of pair is as a space-time sheet with size of order ξ so that the electrons are "outside" the background space-time. Could the Coulomb interaction energy of electrons with positively charged wormhole throats carrying parton numbers and feeding em gauge flux to the large space-time sheet be responsible for the gap energy? Could wormhole throats carry also quark quantum numbers and form color singlet like structures connected by long color flux tubes so that color force would be ultimately responsible for the stability of Cooper pair? In case of single electron condensed to single space-time sheet the em flux could be indeed feeded by u and $\overline{d}$ type wormhole contacts to larger space-time sheet. Or could electrons be free-travellers bound to structures involving also other particles?

3. Quantum classical correspondence forces to ask for the space-time correlates for the existing quantum description of phonons.
   Questions: What are the space-time sheets associated with phonons? Could the microscopic description of phonons in atomic length scales rely on the oscillations of wormhole contact Bose-Einstein condensates at the boundaries of nucleon space-time sheets with size scale of order atom size? Could the dark weak length scale which is of order atomic size replace lattice constant in the expression of sound velocity? What is the space-time correlate for sound velocity?

4. The new super-conductors possess relatively complex chemistry and lattice structure.
   Questions: Could it be that complex chemistry and lattice structure makes possible something very simple which is a transition to dark nuclear phase so that size of dark quarks involved would be scaled up to $L(k \to k+22 \to k+44)$, say $k = 113 \to 135 \to 157$), and the size of hadronic space-time sheets would be scaled up as $k = 107 \to 129 \to 151$? Could it be that also other p-adic primes are possible as suggested by the p-adic

mass calculations of hadron masses predicting that hadronic quarks can correspond to several values of k? Could it be that the Gaussian Mersennes $(1+i)^k - 1$, $k = 151, 157, 163, 167$ spanning the p-adic length scale range 10 nm-2.5 μm correspond to p-adic length especially relevant for super-conductivity.

2.4.2 Photon massivation, coherent states of Cooper pairs, and wormhole contacts

The existence of wormhole contacts have been one of the most exotic predictions of TGD. The realization that wormhole contacts can be regarded as parton-antiparton pairs with parton and antiparton assignable to the light-like causal horizons accompanying wormhole contacts, and that Higgs particle corresponds to wormhole contact [F2], opens the doors for more concrete models of also super-conductivity involving massivation of photons.

The formation of a coherent state of wormhole contacts would be the counterpart for the vacuum expectation value of Higgs. The notions of coherent states of Cooper pairs and of charged Higgs challenge the conservation of electromagnetic charge. The following argument however suggests that coherent states of wormhole contacts form only a part of the description of ordinary super-conductivity. The basic observation is that wormhole contacts with vanishing fermion number define space-time correlates for Higgs type particle with fermion and antifermion numbers at light-like throats of the contact.

The ideas that a genuine Higgs type photon massivation is involved with super-conductivity and that coherent states of Cooper pairs really make sense are somewhat questionable since the conservation of charge and fermion number is lost. A further questionable feature is that a quantum superposition of many-particle states with widely different masses would be in question. The interpretational problems could be resolved elegantly in zero energy ontology [C2] in which the total conserved quantum numbers of quantum state are vanishing. In this picture the energy, fermion number, and total charge of any positive energy state are compensated by opposite quantum numbers of the negative energy state in geometric future. This makes possible to speak about superpositions of Cooper pairs and charged Higgs bosons separately in positive energy sector.

Rather remarkably, if this picture is taken seriously, super-conductivity can be seen as providing a direct support for both the hierarchy of scaled variants of standard model physics and for the zero energy ontology.

2.4.3 Phonon exchange mechanism

Sound waves correspond to density variations of condensed matter. If dark gluons and exotic weak bosons with weak scale of order atomic radius explain the low compressibility of condensed matter [F10] then these forces should be essential for the description of what happens for sound waves below the atomic

length scale. In particular, the lattice length appearing in Debye frequency should be expressible in terms of dark weak length scale.

Quantum classical correspondence requires that phonons should have identification as space-time sheets and that sound velocity is coded in the geometry of the space-time sheet. This interpretation of course makes sense only if the space-time sheet of phonon is in contact with atoms so that atomic oscillations induce oscillations of the induced gauge fields inside it.

The obvious objection against this picture is that one can imagine the possibility of free phonons analogous to photons connecting nuclei with say distance of micrometer and having no contact with the nuclei in between. One can of course turn the situation around and ask whether free phonons are the hen and lattice oscillations the egg. Could free photons exist and induce resonant oscillations of atomic nuclei if their velocity is consistent with the sound velocity deducible from the lattice constant and elastic constant for the interactions between atoms?

The existence of warped vacuum extremals, and in general the huge vacuum degeneracy of field equations, suggest how this space-time representation of phonons might occur. The simplest warped extremal corresponds to the mapping $M^4 \to CP_2$ defined as $\Phi = \omega m^0$, where Φ is coordinate of the geodesic circle of CP_2 with other coordinates being constant. The induced metric is $g_{m^0m^0} = 1 - R^2\omega^2/4$, $g_{ij} = -\delta_{ij}$. Light velocity with respect to M^4 coordinates, which are physically preferred coordinates, is reduced to $v = \sqrt{1 - R^2\omega^2/4}$. The crazy guess would be that the reduced signal velocity could have interpretation as sound velocity with the previous prerequisites.

For small perturbations of vacuum extremals the term coming from the variation with respect to the induced metric vanishes, and the only contribution comes from the variation of the induced Kähler form. As a consequence, the field equations reduce to empty space Maxwell's equations $j_K^\alpha = 0$ for the induced Kähler form in the induced metric of determined by vacuum extremal in the lowest non-trivial order. This means that the maximal signal velocity is in general reduced and the reduction can be very large as the case of warped vacuum extremals demonstrates. The longitudinal Kähler electric field associated with phonons would serve as a correlate for the longitudinal sound waves.

In higher orders the solution develops a non-vanishing Kähler current j_K^α and this relates naturally to the fact that the phonon exchange involves dissipation. In the case of the simplest warped vacuum extremals the relevant parameter for the perturbation theory is ωR which is near to unity so that perturbative effects can be quite sizable if the phonons are representable in the proposed manner. The non-vanishing of the vacuum Lorentz force $j_K^\alpha J_{\alpha\beta}$ serves as a space-time correlate for the presence of dissipative effects. For the known solutions of field equations the Lorentz force vanishes and the interpretation is that they represent asymptotic self-organization patters. Phonons would be different and represent transient phenomena.

If this interpretation is correct, the phonon mechanism for the formation of Cooper pairs could have a description in terms of the topological condensa-

tion of electrons at space-time sheets representing phonons connecting atomic nuclei. The essential point would be that electrons of Cooper pair would be outside the space-time in well-defined sense. Also now wormhole contacts would be involved but the Coulomb interaction energy of delocalized electrons with charged wormhole throats would be negligible as compared to the interaction energy with nuclei.

2.4.4 Space-time correlate for quantum critical superconductivity

The series of leading questions has probably given reader a hunch about what the mechanism of super-conductivity could be in the quantum critical case.

1. Exotic Cooper pair as a pair of space-time sheets of scaled up electrons feeding their gauge fluxes to a larger space-time sheet via $q\bar{q}$ type wormhole contacts

Quantum critical electronic super-conductivity requires new kind of Cooper pairs which are responsible for supra currents in the temperature range $[T_c, T_{c_1}]$ inside stripe like regions (flux tubes). These Cooper pairs are quantum critical against decay to ordinary electrons so that in time scale characterizing quantum criticality so that super-conductivity is reduced to conductivity whose temperature dependence is characterized by scaling laws. Below T_c large $\hbar$ variants of BCS Cooper pairs are good candidates for supra current carriers and would result from exotic Cooper pairs. A model for the exotic Cooper pairs is considered in the sequel. Boundary plays an essential role in that the Cooper pairs at boundary must be in quantum critical phase also below T_c since otherwise the transformation of ordinary electrons to large $\hbar$ BCS type Cooper pairs and vice versa is not possible.

If wormhole contact for large $\hbar$ electron corresponds to e^+e^- pairs, one ends up with a stability problem since the annihilation of electron and e^+ at wormhole throat can lead to the disappearance of the space-time sheet. If there are two wormhole contacts corresponding to quark anti-quark pairs the situation changes. The requirement that the net charge of wormhole throats is +2e implies $u\bar{d}$ configuration for upper wormhole throats and its conjugate for the lower wormhole throats. If the wormhole throats of each electron carry net color quantum numbers the binding of electrons by color confining force would guarantee the stability of the exotic Cooper pair. This would require that wormhole throats form a color singlet not reducible to product of pion type $u\bar{d}$ type color singlets.

BCS type Cooper pair results when both electrons end up at same space-time sheet of exotic Cooper pair via a join along boundaries bond. This hopping would also drag the wormhole contacts with it and the second space-time sheet could contract. These Cooper pairs can in principle transform to pairs involving only two join along boundaries contacts carrying e^+e^- pairs at their throats. For these Cooper pairs case the binding of electrons would be due to phonon mechanism.

2. General comments

Some general comments about the model are in order.

1. High T_c super conductors are Mott insulators and antiferromagnets in their ground state, which would suggest that the notion of non-interacting Fermi gas crucial for BCS type description is not useful. Situation is however not so simple if antiferromagnetic phase and magnetically disordered phase with large $\hbar$ for nuclei compete at quantum criticality. Large $\hbar$ makes possible high T_c variant of BCS type superconductivity in magnetically disordered phase in interior of rivulets but it is possible to get to this phase only via a phase consisting of exotic Cooper pairs and this is possible only in finite temperature range below T_c.

2. For both exotic and phonon mediated super-conductivity Cooper pair can be said to be outside the space-time sheet containing matter. Assuming a complete delocalization in the exotic case, the interaction energy is the expectation value of the sum of kinetic and Coulombic interaction energies between electrons and between electrons and wormhole throats. In the case of phonon space-time sheets situation is different due to the much larger size of Cooper pair space-time sheet so that Coulomb interaction with wormhole throats provides the dominating contribution to the binding energy.

3. The explicit model for high T_c super-conductivity relies on quantum criticality involving long ranged quantum fluctuations. The mechanism seems could apply in all cases where quantum critical fluctuations can be said to be carriers of supra currents and exotic super-conductivity vanishes when either phase dominates completely. In the case of high T_c super-conductors quantum criticality corresponds to a quite wide temperature range, which provides support for the quantum criticality of TGD Universe.

2.5 Super-conductivity at magnetic flux tubes

Super-conductivity at magnetic flux tubes of magnetic flux quanta is one the basic hypothesis of the TGD based model of living matter. There is also evidence for magnetically mediated super-conductivity in extremely pure samples [32]. The magnetic coupling was only observed at lattice densities close to the critical density at which long-range magnetic order is suppressed. Quantum criticality suggests that the super-conductivity appears at the boundaries of two competing phases and that Cooper pairs correspond to space-time sheets feeding their em gauge charge via $q\bar{q}$ type wormhole contacts to larger space-time sheet.

Almost the same model as in the case of high T_c and quantum critical superconductivity applies to magnetic flux tubes. Now the flux quantum contains BE condensate of exotic Cooper pairs interacting with wormhole contacts feeding the gauge flux of Cooper pairs from the magnetic flux quantum to a larger space-time sheet. The interaction of spin 1 Cooper pairs with the magnetic

field of flux quantum orients their spins in the same direction. Large value of $\hbar$ guarantees thermal stability even in the case that different space-time sheets are not thermally isolated.

2.5.1 Superconductors at the flux quanta of the Earth's magnetic field

Magnetic flux tubes and magnetic walls are the most natural candidates for super-conducting structures with spin triplet Cooper pairs. Indeed, experimental evidence relating to the interaction of ELF em radiation with living matter suggests that bio-super-conductors are effectively 1- or 2-dimensional. $D \leq 2$-dimensionality is guaranteed by the presence of the flux tubes or flux walls of, say, the magnetic field of Earth in which charge carries form bound states and the system is equivalent with a harmonic oscillator in transversal degrees of freedom.

The effect of Earth's magnetic field is completely negligible at the atomic space-time sheets and cannot make super conductor 1-dimensional. At cellular sized space-time sheets magnetic field makes possible the confinement of the electron Cooper pairs in harmonic oscillator states. The critical temperature is however extremely low for ordinary value of $\hbar$ and either thermal isolation between space-time sheets or large value of $\hbar$ can save the situation.

An essential element of the picture is that topological quantization of the magnetic flux tubes occurs. In fact, the flux tubes of Earth's magnetic field have thickness of order cell size from the quantization of magnetic flux. The observations about the effects of ELF em fields on bio-matter [77, 85] suggest that similar mechanism is at work also for ions and in fact give very strong support for bio-super conductivity based on the proposed mechanism.

2.5.2 Energy gaps for superconducting magnetic flux tubes and walls

Besides the formation of Cooper pairs also Bose-Einstein condensation to the ground state occurs and the stability of Bose-Einstein condensate requires an energy gap which must be larger than the temperature at the magnetic flux tube.

There are several energies to be considered.

1. The Coulombic binding energy of Cooper pairs with the wormhole contacts feeding the em flux from magnetic flux tube to a larger space-time sheet defines an energy gap which is expected to be of order $E_g = \alpha/L(k)$ giving $E_g \sim 10^{-3}$ eV for $L(167) = 2.5$ μm giving a rough estimate for the thickness of the magnetic flux tube of the Earth's magnetic field $B = .5 \times 10^{-4}$ Tesla.

2. In longitudinal degrees of freedom of the flux tube Cooper pairs can be described as particles in a one-dimensional box and the gap is characterized by the length L of the magnetic flux tube and the value of $\hbar$. In longitudinal degrees of freedom the difference between $n = 2$ and $n = 1$

states is given by $E_0(k_2) = 3h^2/4m_eL^2(k_2)$. Translational energy gap $E_g = 3E_0(k_2) = 3h^2/4m_eL^2(k_2)$ is smaller than the effective energy gap $E_0(k_1) - E_0(k_2) = h^2/4m_eL^2(k_1) - h^2/4m_eL^2(k_2)$ for $k_1 > k_2 + 2$ and identical with it for $k_1 = k_2 + 2$. For $L(k_2 = 151)$ the zero point kinetic energy is given by $E_0(151) = 20.8$ meV so that E_g corresponds roughly to a temperature of 180 K. For magnetic walls the corresponding temperature would be scaled by a factor of two to 360 K and is above room temperature.

3. Second troublesome energy gap relates to the interaction energy with the magnetic field. The magnetic interaction energy E_m of Cooper pair with the magnetic field consists of cyclotron term $E_c = n\hbar eB/m_e$ and spin-interaction term which is present only for spin triplet case and is given by $E_s = \pm\hbar eB/m_e$ depending on the orientation of the net spin with magnetic field. In the magnetic field $B_{end} = 2B_E/5 = .2$ Gauss ($B_E = .5$ Gauss is the nominal value of the Earth's magnetic field) explaining the effects of ELF em fields on vertebrate brain, this energy scale is $\sim 10^{-9}$ eV for ordinary value of $\hbar$ and $\sim 2n \times 10^{-6}$ eV for $\hbar = n2^{11} \times \hbar(1)$. At the next level of dark hierarchy the energy would be $4n^2 \times 10^{-3}$ eV and would still correspond to a temperature $4n^2$ K.

The smallness of translational and magnetic energy gaps in the case of Cooper pairs at Earth's magnetic field could be seen as a serious obstacle.

1. Thermal isolation between different space-time sheets provides one possible resolution of the problem. The stability of the Bose-Einstein condensation is guaranteed by the thermal isolation of space-time if the temperature at the magnetic flux tube is below E_m. This can be achieved in all length scales if the temperature scales as the zero point kinetic energy in transversal degrees of freedom since it scales in the same manner as magnetic interaction energy.

2. The transition to large $\hbar$ phase could provide a more elegant way out of the difficulty. The criterion for a sequence of transitions to a large $\hbar$ phase could be easily satisfied if there is a large number of charge Cooper pairs at the magnetic flux tube. Kinetic energy gap remains invariant if the length of the flux tube scales as $\hbar$. If magnetic flux is quantized as a multiple of $\hbar$ and flux tube thickness scales as $\hbar^2$, B must scale as $1/\hbar$ so that also magnetic energy remains invariant under the scaling. This would allow to have stability without assuming low temperature at magnetic flux tubes.

3 TGD based model for high T_c super conductors

The model of exotic Cooper pairs has been already described and since high T_c superconductors are quantum critical, they provide an attractive application of the model.

3.1 Some properties of high T_c super conductors

Quite generally, high T_c super-conductors are cuprates with CuO layers carrying the supra current. The highest known critical temperature for high T_c superconductors is 164 K and is achieved under huge pressure of 3.1×10^5 atm for LaBaCuO. High T_c super-conductors are known to be super conductors of type II.

This is however a theoretical deduction following from the assumption that the value of Planck constant is ordinary. For $\hbar = 2^{11}\hbar_0$ ξ would be scaled up accordingly and type I super-conductor would be in question. These superconductors are characterized by very complex patterns of penetrating magnetic field near criticality since the surface area of the magnetic defects is maximized. For high T_c super-conductors the ferromagnetic phase could be regarded as an analogous defect and would indeed have very complex structure. Since quantum criticality would be in question the stripe structure would fluctuate with time too in accordance with 4-D spin glass character.

The mechanism of high T_c super conductivity is still poorly understood [41, 51]. It is agreed that electronic Cooper pairs are charge carriers. It is widely accepted that electrons are in relative d-wave state rather than in s-wave (see [40] and the references mentioned in [41]). Cooper pairs are believed to be in spin triplet state and electrons combine to form $L = 2$ angular momentum state. The usual phonon exchange mechanism does not generate the attractive interaction between the members of the Cooper pair having spin. There is also a considerable evidence for BCS type Cooper pairs and two kinds of Cooper pairs could be present.

High T_c super conductors have spin glass like character [39]. High T_c superconductors have anomalous properties also above T_c suggesting quantum criticality implying fractal scaling of various observable quantities such as resistivity. At high temperatures cuprates are anti-ferromagnets and Mott insulators meaning freezing of the electrons. Superconductivity and conductivity is known to occur along dynamical stripes which are antiferromagnetic defects.

These findings encourage to consider the interpretation in terms of quantum criticality in which some new form of super conductivity which is not based on quasiparticles is involved. This super-conductivity is assignable with the quantum fluctuations destroying antiferromagnetic order and replacing it with magnetically disordered phase possibly allowing phonon induced super-conductivity.

The doping of the super-conductor with electron holes is essential for high T_c superconductivity and the there is a critical doping fraction $p = .14$ at which T_c is highest. There is considerable evidence that holes gather on one-dimensional stripes with thickness of order few atom sizes and lengths in the range 1-10 nm [51], which are fluctuating in time scale of 10^{-12} seconds. These stripes are also present in non-conductong and non-superconducting state but in this case they do not fluctuate. One interpretation for the fluctuations is as oscillations analogous to acoustic wave and essential for the binding of Cooper pairs. Quantum criticality suggests an alternative interpretation.

T_c is inversely proportional to the distance L between the stripes. One inter-

pretation is in terms of generalization of the Debye frequency to 2-dimensional case. One could also consider phonons with wavelength equal to the distance between the stripes. A further interpretation would be that full super-conductivity requires delocalization of electrons also with respect to stripes so that T_c would be proportional to the hopping probability of electron between neighboring stripes expected to be proportional to $1/L$ [51]. Later a TGD based interpretation will be discussed.

3.1.1 From free fermion gas to Fermi liquids to quantum critical systems

The article of Jan Zaanen [47] gives an excellent non-technical discussion of various features of high T_c super-conductors distinguishing them from BCS super-conductors. After having constructed a color flux tube model of Cooper pairs I found it especially amusing to learn that the analogy of high T_c superconductivity as a quantum critical phenomenon involving formation of dynamical stripes to QCD in the vicinity of the transition to the confined phase leading to the generation of string like hadronic objects was emphasized also by Zaanen.

BCS super-conductor behaves in a good approximation like quantum gas of non-interacting electrons. This approximation works well for long ranged interactions and the reason is Fermi statistics plus the fact that Fermi energy is much larger than Coulomb interaction energy at atomic length scales.

For strongly interacting fermions the description as Fermi liquid (a notion introduced by Landau) has been dominating phenomenological approach. ^{3}He provides a basic example of Fermi liquid and already here a paradox is encountered since low temperature collective physics is that of Fermi gas without interactions with effective masses of atoms about 6 times heavier than those of real atoms whereas short distance physics is that of a classical fluid at high temperatures meaning a highly correlated collective behavior.

Many-sheeted space-time provides a possible explanation of the paradox. Space-time sheets containing join along boundaries blocks of ^3He atoms behave like gas whereas the ^3He atoms inside these blocks form a liquid. An interesting question is whether the ^3He atoms combine to form larger units with same spin as ^3He atom or whether the increase of effective mass by a factor of order six means that $\hbar$ as a unit of spin is increased by this factor forcing the basic units to consist of Bose-Einstein condensate of 3 Cooper pairs.

High Tc super conductors are neither Fermi gases nor Fermi liquids. Cuprate superconductors correspond at high temperatures to doped Mott insulators for which Coulomb interactions dominate meaning that electrons are localized and frozen. Electron spin can however move and the system can be regarded as an anti-ferromagnet. CuO planes are separated by highly oxidic layers and become super-conducting when doped. The charge transfer between the two kinds of layers is what controls the degree of doping. Doping induces somehow a delocalization of charge carriers accompanied by a local melting of anti-ferromagnet.

Collective behavior emerges for high enough doping. Highest T_c results with 15 per cent doping by holes. Current flows along electron stripes. Stripes

themselves are dynamical and this is essential for both conductivity and superconductivity. For completely static stripes super-conductivity disappears and quasi-insulating electron crystal results.

Dynamical stripes appear in mesoscopic time and length scales corresponding to 1-10 nm length scale and picosecond time scale. The stripes are in a well-defined sense dual to the magnetized stipe like structures in type I superconductor near criticality, which suggests type I super-conductivity: as found large $\hbar$ Cooper pairs would make it possible. The stripes are anti-ferromagnetic defects at which neighboring spins fail to be antiparallel. It has been found that stripes are a very general phenomenon appearing in insulators, metals, and superconducting compounds [50].

3.1.2 Quantum criticality is present also above T_c

Also the physics of Mott insulators above T_c reflects quantum criticality. Typically scaling laws hold true for observables. In particular, resistivity increases linearly rather than transforming from T^2 behavior to constant as would be implied by quasi-particles as current carriers. The appearance of so called pseudogap [48] at $T_{c1} > T_c$ conforms with this interpretation. In particular, the fact pseudo-gap is non-vanishing already at T_{c_1} and stays constant rather than starting from zero as for quasi-particles conforms with the flux tube interpretation.

3.1.3 Results from optical measurements and neutron scattering

Optical measurements and neutron scattering have provided especially valuable microscopic information about high T_c superconductors allowing to fix the details of TGD based quantitative model.

Optical measurements of copper oxides in non-super-conducting state have demonstrated that optical conductivity $\sigma(\omega)$ is surprisingly featureless as a function of photon frequency. Below the critical temperature there is however a sharp absorption onset at energy of about 50 meV [42]. The origin of this special feature has been a longstanding puzzle. It has been proposed that this absorption onset corresponds to a direct generation of an electron-hole pair. Momentum conservation implies that the threshold for this process is $E_g + E$, where E is the energy of the 'gluon' which binds electrons of Cooper pair together. In case of ordinary super-conductivity E would be phonon energy.

Soon after measurements, it was proposed that in absence of lattice excitations photon must generate two electron-hole pairs such that electrons possess opposite momenta [42]. Hence the energy of the photon would be $2E_g$. Calculations however predicted soft rather than sharp onset of absorption since pairs of electron-hole pairs have continuous energy spectrum. There is something wrong with this picture.

Second peculiar characteristic [43, 44, 45] of high T_c super conductors is resonant neutron scattering at excitation energy $E_w = 41$ meV of super conductor. This scattering occurs only below the critical temperature, in spin-flip channel and for for favored momentum exchange $(\pi/a, \pi/a)$), where a denotes the size

of the lattice cube [43, 44, 45]. The transferred energy is concentrated in a remarkably narrow range around E_w rather than forming a continuum.

In [34] is is suggested that e-e resonance with spin one gives rise to this excitation. This resonance is assumed to play the same role as phonon in ordinary super conductivity and ee resonance is treated like phonon. It is found that one can understand the dependence of the second derivative of the photon conductivity $\sigma(\omega)$ on frequency and that consistency with neutron scattering data is achieved. The second derivative of $\sigma(\omega)$ peaks near 68 meV and assuming $E = E_g + E_w$ they found nearly perfect match using $E_g = 27$ meV. This would suggest that the energy of the excitations generating the binding between the members of the Cooper pair is indeed 41 meV, that two electron-hole pairs and excitation of the super conductor are generated in photon absorption above threshold, and that the gap energy of the Cooper pair is 27 meV. Of course, the theory of Carbotte *et al* does not force the 'gluon' to be triplet excitation of electron pair: also other possibilities can be considered.

3.2 Vision about high T_c superconductivity

The following general view about high T_c super-conductivity as quantum critical phenomenon suggests itself.

3.2.1 Interpretation of critical temperatures

The two critical temperatures T_c and $T_{c_1} > T_c$ are interpreted as critical temperatures. T_{c_1} is the temperature for the formation of a quantum critical phase consisting of ordinary electrons and exotic Cooper pairs with large value of Planck constant. Quantum criticality of exotic Cooper pairs prevails for temperatures below T_{c_1} in the case that one has conductivity. For completely static stripes there is no conductivity. The absence of fluctuations suggests the loss of quantum criticality. One interpretation could be that exotic Cooper pairs are there but there can be no conductivity since the necessary transition of incoming ordinary electrons to large $\hbar$ dark electrons and back is not possible. T_c is the temperature at which BCS type Cooper pairs with large Planck constant become possible and exotic Cooper pairs can decay to the ordinary Cooper pairs.

3.2.2 Model for exotic and BCS type Cooper pairs

Exotic Cooper pair is modelled as a pair of large $\hbar$ electrons with zoomed up size at space-time sheets X^4_c topologically condensed to the background space-time sheet Y^4 of condensed matter system. The Coulombic binding energy of charged particles with the quarks and antiquarks assignable to the two wormhole throats feeding the em gauge flux to Y^4 could be responsible for the energy gap. Color force would bind the two space-time sheets to exotic Cooper pair.

Electrons of exotic Cooper pair can also end up a to same space-time sheet and possibly but not necessarily feed their em fluxes via two wormhole contacts

carrying electron-positron pairs. In this case they are bound by the usual phonon interaction and form ordinary Cooper pair with large value of Planck constant.

The origin of the large $\hbar$ electrons must somehow relate to the breaking of antiferromagnetic phase by stripes. The neighboring electrons in stripe possess parallel spins and could therefore form a pair transforming to a large $\hbar$ Cooper pair bound by color force. This mechanism would be the TGD counterpart for the mechanism allowing the superconducting phases at different stripes to fuse to a single super-conducting phase at longer length scales.

Various lattice effects such as superconductivity-induced phonon shifts and broadenings, isotope effects in T_c, the penetration depth, infrared and photoemission spectra have been observed in the cuprates [49]. This would support the view that quantum criticality involves the competition between exotic and large $\hbar$ variant of BCS type super-conductivity and the proposed mechanism transforming exotic Cooper pair to BCS type pairs. The loss of antiferromagnetic order for higher dopings would make possible BCS type phonon induced super-conductivity with spin singlet Cooper pairs.

3.2.3 What is the value of $\hbar$?

The observed stripes would carry large $\hbar_{eff}$ electrons attracted to them by hole charge. The basic question concerns the value of $\hbar_{eff}$ which in the general case is given by $\hbar_{eff} = n_a/n_b$ where n_i is the order of the maximal cyclic subgroup of G_i.

1. The thickness of stripes is few atomic sizes and the first guess is that scaled up electrons have atomic size. The requirement that the integer n_a defining the value of M^4 Planck constant correspond to a n-polygon constructible using only ruler and compass gives strong constraints. An even stronger requirement would be that subgroup $G_a \subset SU(2)$ characterizes the Jones inclusion involved and thus the covering of CP_2 by M^4 points, corresponds to exceptional group via McKay correspondence, leaves only one possibility: $N(G_b) = 120$ which corresponds to E_8 Dynkin diagram having Z_5 as maximal cyclic subgroup and involving Golden Mean. The p-adic length scale of electron would be scaled up: $L(127) \to 5L(127) \simeq L(127+12) = L(139) \simeq 1.6$ Angstrom. This picture is not consistent with the model involving cell membrane length scale and the appearance of 50 meV energy scale which can be interpreted in terms of Josephson energy for cell membrane at criticality for nerve pulse generation is too intriguing signal to be dismissed.

2. The length of stripes is in the range 1-10 nm and defines second length scale in the system. If the Compton wavelength of scaled up electron corresponds to this length then $n_a = n_F = 2^{11}$ whose powers are encountered in the quantum model of living matter would suggest itself, and would predict the effective p-adic length scale electron to be $L(127 + 22) = L(149) = 5$ nm, the thickness of the lipid layer of the cell membrane which brings in mind cell membrane and bio-superconductivity. It will be found that

simple stability arguments favor this size scale for scaled up electrons and size $L(151)$ for the exotic Cooper pairs. The minimum option is that only the exotic Cooper pairs making possible super-conductivity above T_c and broken by quantum criticality against transition to ordinary electron need have size of order $L(151) = 10$ nm.

3. The coherence length for high T_c super conductors is reported to 5-20 Angstroms. The naive interpretation would be as the size of BCS type Cooper pair which would suggest that scaled up electrons have at most atomic size. There is however a loophole involved. The estimate for coherence length in terms of gap energy is given by $\xi = \frac{4\hbar v_F}{E_{gap}}$. If coherence length is estimated from the gap energy, as it seems to be the case, then the scaling up of Planck constant would increase coherence length by a factor n_F and give coherence length in the range $1 - 4$ μm.

4. The dependence $T_c \propto 1/L$, where L is the distance between stripes is a challenge for the model since it would seem to suggest that stripe-stripe interaction is important for the energy gap of BCS type Cooper pairs. One can however understand this formula solely in terms of 2-dimensional character of high T_c super-conductors. To see this, consider generalization of the 3-D formula

$$E_{gap} = \hbar\omega_c exp(-1/X)$$
$$\omega_D = (6\pi^2)^{1/3} c_s n_n^{1/3}$$

for the gap energy to 2-dimensional case. Since only the nuclei inside stripes contribute to high T_c super-conductivity it is natural to replace 3-dimensional formula for Debye frequency in 2-dimensional case with

$$\omega_D = k c_s n_h^{1/2} \quad ,$$

where n_h is the 2-dimensional density of holes and k a numerical constant. Since one has $n_h \propto 1/L^2$ this indeed predicts $E_{gap} \propto 1/L$.

3.2.4 Quantum criticality below T_{c_1}

Exotic Cooper pairs would be present below the higher critical temperature T_{c_1} associated with high T_c super-conductors and start to transform to BCS type Cooper pairs at T_c. Also the reverse process occurs. In the intermediate temperature range they would be unstable against transition changing the value of Planck constant to ordinary ones and this instability would break the exotic super-conductivity to ordinary conductivity with resistance obeying scaling law as a function of temperature typical for quantum critical systems. The complete stability of stripes would indicate that the exotic Cooper pairs are present but conductivity is not possible since ordinary electrons entering to the system cannot transformed to exotic Cooper pairs.

3.2.5 Why doping by holes is necessary?

In high T_c super-conductivity doping by holes plays a crucial role. What is known that holes gather to the stripes and that there is a critical doping at which T_c is maximum. Cusp catastrophe as a general model for phase transition suggests that that super-conductivity is possible only in finite range for the hole concentration. This is indeed the case.

The holes form a positive charge density and this inspires the idea that Coulomb attraction between exotic Cooper pairs of electrons and holes leads to the formation of stripes. Stripes provide also electrons with parallel spins which can transform to exotic large $\hbar$ Cooper pairs at quantum criticality with respect to $\hbar$.

One should also understand the upper limit for the hole concentration.

1. The first explanation is that super-conductivity is not preserved above critical hole concentration due to the loss of fractal stripe structure. Part of the explanation could be that beyond critical hole concentrations it is not possible to arrange the stripes to a fractal lattice formed by a lattice of "super-stripes" which are lattices of stripes of thickness $L(151)$ containing the observed stripes such that super-stripes have separation $d \geq L(151)$. Doping fraction p gives an estimate for the distance d between super-stripes as $d = xL(151)$, $x = r/p - 1$, where r is the fraction of atoms belonging to stripe inside super-stripe and p is doping fraction. $x = 2/5$ and $p = .15$ gives $d = 5L(151)/3$. Note that ideal fractality would require $x/(1+x) = r$ giving $r \simeq p/2$.

2. One could also consider the possibility that large $\hbar$ BCS super-conductivity is not lost above critical hole concentration but is useless since the transformation of ordinary current carrying electrons to large $\hbar$ exotic Cooper pairs would not be possible. Thus a quantum critical interface allowing to transform ordinary current to supra current is necessary.

3.2.6 Zeros of Riemann ζ and quantum critical super conductors

A long standing heuristic hypothesis has been that the radial conformal weights Δ assignable to the functions $(r_M/r_0)^\Delta$ of the radial lightlike coordinate r_M of $\delta M^4_+/-$ of lightcone boundary in super-canonical algebra consisting of functions in $\delta M^4_\pm \times CP_2$ are expressible as linear combinations of zeros of Riemann Zeta. Quantum classical correspondence in turn inspires the hypothesis that these conformal weights can be mapped to the points of a geodesic sphere of CP_2 playing the role of conformal heavenly sphere.

The arguments of [C1] suggest that radial conformal weight Δ in fact depends on the point of geodesic sphere S^2 in CP_2 and is given in terms of the inverse $\zeta^{-1}(z)$ of Riemann ζ having the natural complex coordinate z of S^2 as argument. This implies a mapping of the radial conformal weights to the points of the geodesic sphere CP_2. Linear combinations of zeros correspond to algebraic points in the intersections of real and p-adic space-time sheets and are

thus in a unique role from the point of view of p-adicization. This if one believes the basic conjecture that the numbers p^s, p prime and s zero of Riemann Zeta are algebraic numbers.

Zeros of Riemann Zeta have been for long time speculated to closely relate to fractal and critical systems. If the proposed general ansatz for super-canonical radial conformal weights holds true, these speculations find a mathematical justification.

Geometrically the transition changing the value of $\hbar(M^4)$ correspond to a leakage of partonic 2-surfaces between different copies of $M^4 \times CP_2$ with same CP_2 factor and thus same value of $\hbar(CP_2)$ but different scaling factor of CP_2 metric. M^4 metrics have the same scaling factor given by n_b^2.

Critical 2-surfaces can be regarded as belonging to either factor which means that points of critical 2-surfaces must correspond to the CP_2 orbifold points, in particular, $z = \xi^1/\xi^2 = 0$ and $z = \xi^1/\xi^2 = \infty$ remaining invariant under the group $G \subset SU(2) \subset SU(3)$ defining the Jones inclusion, that is the north and south poles of homologically non-trivial geodesic sphere $S^2 \subset CP_2$ playing the role of heavenly sphere for super-canonical conformal weights. If the hypothesis $\Delta = \zeta^{-1}(z)$ is accepted, the radial conformal weight corresponds to a zero of Riemann Zeta: $\Delta = s_k$ at quantum criticality.

At quantum level a necessary prerequisite for the transition to occur is that radial conformal weights, which are conserved quantum numbers for the partonic time evolution, satisfy the constraint $\Delta = s_k$. The partonic 2-surfaces appearing in the vertices defining S-matrix elements for the phase transitions in question need not be of the required kind. It is enough that $\Delta = s_k$ condition allows their evolution to any sector of H in question. An analogous argument applies also to the phase transitions changing CP_2 Planck constant: in this case however leakage occurs through a partonic 2-surface having single point as M^4 projection (the tip of $M^4_\pm$).

Quantum criticality for high temperature super-conductivity could provide an application for this vision. The super conducting stripe like regions are assumed to carry Cooper pairs with a large value of M^4 Planck constant corresponding to $n_a = 2^{11}$. The boundary region of the stripe is assumed to carry Cooper pairs in critical phase so that super-canonical conformal weights of electrons should satisfy $\Delta = s_k$ in this region. If the members of Cooper pair have conjugate conformal weights, the reality of super-canonical conformal weight is guaranteed. The model predicts that the critical region has thickness $L(151)$ whereas scaled electron with $n = 2^{11}$ effectively correspond to $L(127 + 22) = L(149)$, the thickness of the lipid layer of cell membrane. This picture would suggests that the formation and stability of the critical region is essential for the formation of phase characterized by high T_c super-conductivity with large value of Planck constant and forces temperature to a finite critical interval. In this framework surface super-conductivity would be critical and interior super-conductivity stable.

These observations in turn lead to the hypothesis that cell interior corresponds to a phase with large M^4 Planck constant $\hbar(M^4) = 2^{11}\hbar_0$ and cell membrane to a quantum critical region where the above mentioned condition

$\Delta = s_k$ is satisfied. Thus it would seem that the possibility of ordinary electron pairs to transform to large $\hbar$ Cooper pairs is essential in living matter and that the transition takes place as the electron pairs traverse cell membrane. The quantum criticality of cell membrane might prevail only in a narrow temperature range around T=37 C. Note that critical temperature range can also depend on the group G having C_n, $n = 2^{11}$ cyclic group as maximal cyclic group (C_n and D_n are the options).

3.3 A detailed model for the exotic Cooper pair

3.3.1 Qualitative aspects of the model

High T_c superconductivity suggests that the Cooper pairs are stripe like structures of length 1-10 nm. The length of color magnetic flux tube is characterized by the p-adic length scale in question and $L(151) = nm$ is highly suggestive for high T_c superconductors.

These observations inspire the following model.

1. The space-time sheet of the exotic Cooper pair is obtained in the following manner. Take two cylindrical space-time sheets which have radius of order $L(149)$. One could of course argue that flux tubes can have this radius only along CuO plane and must flattened in the direction orthogonal to the super-conducting plane with thickness of few atomic units in this direction. The assumption about flattening leads however to a very large electronic zero point kinetic energy. Furthermore, in the absence of flattening supra phases belonging to different CuO planes combine to form single quantum coherent phase so that coherence length can be longer than the thickness of CuO layer also in orthogonal direction.

2. Assume that the cylinders they contain electrons with u wormhole throat at top and $\overline{d}$ wormhole throat at bottom feeding the em gauge flux to the larger space-time sheet. Connect these parallel flux tubes with color magnetic bonds. If the $u\overline{d}$ states associated with the flux tubes are not in color singlet states, color confinement between wormhole quarks binds the electronic space-time sheets together and electrons are "free-travellers". These exotic Cooper pairs are energy minima for electrons are in large $\hbar$ phase if the electron kinetic energy remains invariant in $\hbar$ changing phase transition. This is achieved by fractionization of quantum numbers characterizing the kinetic energy of electron.

3. If the flux tubes carry magnetic flux electron spins are parallel to the magnetic field in minimum energy state. If the magnetic flux rotates around the resulting singlet sheeted structure the spin directions of electrons are opposite and only $S = 0$ state is possible as a minimum energy state since putting electrons to the same flux tube would give rise to a repulsive Coulomb interaction and also Fermi statistics would tend to increase the energy.

4. The homological magnetic monopoles made possible by the topology of CP_2 allows the electrons to feed their magnetic fluxes to a larger space-time sheet via u throat where it returns back via $\overline{d}$ throat. A 2-sheeted monopole field is in question. The directions of the magnetic fluxes for the two electrons are independent. By connecting the flux tubes by color bonds one obtains color bound electrons. In this kind of situation it is possible to have $S = 1$ state even when electrons are at different flux tubes portions so that energies are degenerate in various cases. The resulting four combinations give $S_z = \pm 1$ states and two $S_z = 0$ states which means spin triplet and singlet. Interestingly, the first 23 year old model of color confinement was based on the identification of color hyper charge as homological charge. In the recent conceptual framework the the space-time correlate for color hyper charge Y of quark could be homological magnetic charge $Q_m = 3Y$ so that color confinement for quarks would have purely homological interpretation at space-time level.

5. One can also understand how electrons of Cooper pair can have angular momentum ($L = 2$ in case of high T_c Cooper pairs and $L = 0$ in case of ^{3}He Cooper pairs) as well as correlation between angular momentum and spin. The generation of radial color electric field determined by the mechanical equilibrium condition $E + v \times B = 0$ inside give portion of flux tube implies that electrons rotate in same direction with velocity v. A non-vanishing radial vacuum E requires that flux tube portion contains cylindrical hole inside it. Without hole only $v = 0$ is possible. Assume that the directions of radial E and thus v can be freely chosen inside the vertical portions of flux tube. Assume that also $v = 0$ is possible in either or both portions. This allows to realize L_z values corresponding to $L = 0, 1, 2$ states.

6. Since quarks in this model appear only as parton pairs associated with wormhole contacts, one expects that the corresponding p-adic mass scale is automatically determined by the relevant p-adic length scale, which would be $L(151)$ in case of high T_c superconductors. This would mean that the mass scale of inertial mass of wormhole contact would be 10^2 eV even in the case that p-adic temperature is $T_p = 1$. For $T_p = 2$ the masses would be extremely small. The fact that the effective masses of electrons can be as high as $100m_e$ [28] means that the mass of wormhole contact does not pose strong constraints on the effective mass of the Cooper pair.

7. The decay of Cooper pair results if electrons are thrown out from 2e space-time sheet. The gap energy would be simply the net binding energy of the system. This assumption can make sense for high T_c super-conductors but does not conform with the proportionality of the gap energy to Debye frequency $\omega_D = v_s/a$ in the case of ordinary super-conductors for which phonon space-time sheets should replace color flux tubes.

8. Both the assumption that electrons condensed at $k = 149$ space-time sheets result from scaled up large $\hbar$ electrons and minimization of energy

imply the the scales $L(149)$ and $L(151)$ for the space-time sheets involved so that there is remarkable internal consistency. The model explains the spins of the exotic Cooper pairs and their angular momenta. The dark BSC type Cooper pairs are expected to have $S = 0$ and $L = 0$.

3.3.2 Quantitative definition of the model

There are several poorly understood energies involved with high T_c super-conductors below T_c. These are $E_g = 27$ meV, $E_1 = 50$ meV, $E_w = 41$ meV, and $E_2 = 68$ meV. These numbers allow to fix the wormholy model for quantum critical super-conductors to a high degree.

Consider now a quantitative definition of the model.

1. p-Adic length scale hypothesis combined with the ideas about high T_c super-conductivity in living matter plus the fact that the stripe like defects in high T_c superconductors have lengths 1-10 nm suggests that the length scales $L(151) = 10$ nm corresponding to cell membrane thickness and $L(149) = 5$ nm corresponding to the thickness of its lipid layer are the most important p-adic length scales. Of course, also $L(145 = 5 \times 29) = 1.25$ nm could be important. $L(151)$ would be associated with the structure consisting of two flux tubes connected by color bonds.

2. The kicking of electrons from $k = 151$ to $k = 149$ space-time sheet should define one possible excitation of the system. For wormhole contacts kicking of electron to smaller space-time sheet is accompanied by the kicking of wormhole contacts from the pair $(151, 157)$ to a pair $(149, 151)$ of smaller space-time sheets. This can be achieved via a flow along JABs $157 \to 151$ and $151 \to 149$. Also the dropping of electrons from color flux tube to larger space-time sheet defines a possible transition.

3. Assume that given electrons reside inside electronic flux tubes connected having u and $\overline{d}$ at their ends and connected by color bonds. Assume that electrons are completely delocalized and consider also the configuration in which both electrons are in the same electronic flux tube. The total energy of the system is the sum of zero point kinetic energies of electrons plus attractive Coulomb interaction energies with u and $\overline{d}$ plus a repulsive interaction energy between electrons which contributes only when electrons are in the same flux tube. Minimum energy state is obviously the one in which electrons are at different flux tubes.

   By effective one-dimensionality the Coulomb potential can be written as $V(z) = \alpha Qz/S$, where S is the thickness of the flux tube. It is assumed that S scales $L(k)^2/y$, $y > 1$, so that Coulomb potential scales as $1/L(k)$. The average values of Coulomb potential for electron quark interaction ($Q(u) = 2/3$ and $Q(\overline{d}) = 1/3$) and ee interaction are

$$V_{eq} \quad = \quad \frac{y}{2} V(k) \ ,$$

$$
\begin{aligned}
V_{ee} &= \frac{y}{3}V(k) \ , \\
V(k) &= \frac{\alpha}{L(k)} \ . \qquad (11)
\end{aligned}
$$

One can introduce a multiplicative parameter x to zero point kinetic energy to take into account the possibility that electrons are not in the minimum of kinetic energy. The color interactions of wormhole throats can of course affect the situation.

With these assumptions the estimate for the energy of the 2e space-time sheet is

$$
\begin{aligned}
E_{2e}(k) &= 2xT(k) - 2V_{eq} + \epsilon V_{ee} = 2xT(k) - y(1-\frac{\epsilon}{3})V(k) \ , \\
T(k) &= \frac{D}{2}\frac{\pi^2}{2m_e L^2(k)} \ , \\
V(k) &= \frac{\alpha}{L(k)} \ . \qquad (12)
\end{aligned}
$$

Here $\epsilon = 1/0$ corresponds to the situation in which electrons are/are not in the same flux tube. One has $x \geq 1$ and $x = 1$ corresponds to the minimum of electron's kinetic energy. If the maximum area of the tube is $\pi L(151)^2$, one should have $y \leq \pi$. The effective dimension is $D = 1$ for flux tube. $k = 151$ and $k = 149$ define the most interesting p-adic length scales now.

4. By p-adic scaling one has

$$
E_{2e}(k) = 2^{151-k} \times 2xT(151) - 2^{(151-k)/2} \times y(1-\frac{\epsilon}{3})V(151) \ . \qquad (13)
$$

The general form of the binding energy implies that it has maximum for some value of k and the maximum turns out to correspond to $k = 151$ with a rather reasonable choice of parameters x and y.

One could also require a stability against the transition $151 \to 149$. Here a difficulty is posed by the fact that color interaction energy of wormhole contacts probably also changes. One can however neglect this difficulty and look what one obtains. In this approximation stability condition reads as

$$
E_{2e}(149) - E_{2e}(151) = 6xT(151) - y(1-\frac{\epsilon}{3})V(151) > 0 \ . \qquad (14)
$$

One obtains

$$\frac{y}{x} \leq \frac{6T(151)}{V(151)} = \frac{6}{\alpha}\frac{\pi^2}{2m_e L(151)} \simeq 3.54 \ . \quad (15)$$

For $k > 151$ the binding energy decreases so fast that maximum of the binding energies at $k = 151$ might be guaranteed by rather reasonable conditions on parameters.

5. The general formula λ is expected to make sense and gives rather large λ. The BCS formula for ξ need not make sense since the notion of free electron gas does not apply. A good guess is that longitudinal ξ is given by the height $L(151) = 10$ nm of the stripe. Transversal ξ, which is in the range 4-20 Angstroms, would correspond to the thickness of the color magnetic flux tube containing electrons. Hence the scale for ξ should be smaller than the thickness of the stripe.

3.3.3 Estimation of the parameters of the model

It turns out to be possible to understand the energies E_2, E_1, E_w and E_g in terms of transitions possible for wormhole contact option. The values of the parameters x and y can be fitted from the following conditions.

1. The largest energy $E_2 = 68$ meV is identified as the binding energy in the situation in which electrons are at different flux tubes. Hence one has $E_{2e}(\epsilon = 0) = -E_2$ giving

$$-2xT(151) + yV(151) = E_2 \ . \quad (16)$$

The peak in photo-absorption cross section would correspond to the dropping of both electrons from the flux tube to a much larger space-time sheet.

2. The energy $E_g = 27$ meV is identified as the binding energy in the situation that electrons are at the same flux tube so that E_g represents the energy needed to kick electrons to a much larger space-time sheet. This gives

$$-2xT(151) + \frac{2}{3}yV(151) = E_g \ . \quad (17)$$

3. E_w corresponds to the difference $E_2 - E_g$ and has an interpretation as the energy needed to induce a transition from state with $\epsilon = 0$ (electrons at different flux tubes) to the state with $\epsilon = 1$ (electrons at the same flux tube).

$$E_{2e}(151,\epsilon=1)-E(2e)(151,\epsilon=0) \quad = \quad \frac{y}{3}V(151)=E_w \quad . \tag{18}$$

This condition allows to fix the value of the parameter y as

$$y \quad = \quad \frac{3E_w}{V(151)} \quad . \tag{19}$$

Condition a) fixes the value of the parameter x as

$$x \quad = \quad \frac{E_w}{T(151)} \quad . \tag{20}$$

Using $V(151) \simeq 144$ meV and $T(151) = 20.8$ meV this gives $y = .8539 < \pi$ and $x = 1.97$. The area of the color flux tube is .27 per cent about $S_{max} = \pi L^2(151)$ so that its radius equals in a good approximation $L(149)$, which looks rather large as compared to the estimated thickness of the visible stripe. $x = 1.97$ means that the electron's kinetic energy is roughly twice the minimal one. $y/x = .43$ satisfies the bound $y/x < 6T(151)/V(151) = .87$ guaranteing that the binding energy is maximum for $k = 151$. This result is rather remarkable.

4. The model should explain also the energy $E_1 \simeq 50$ meV at which sharp photon absorption sets on. The basic observation is that for neuronal membrane 50 mV corresponds to the critical voltage for the generation of nerve pulse. In super-conductor model of cell membrane 50 meV is identified as the energy of Josephson photon emitted or absorbed when Cooper pair moves from cell interior to exterior of vice versa. Thus 50 meV energy *might* correspond to the energy of Josephson photon and kick BCS type Cooper pair between the two layers of the double-layered super stripe.

   Note that 50 meV corresponds to a thermal energy of 3-D system at T= 333 K (60 C). This is not far from 37 C, which would also suggest that high T_c super-conductivity is possible at room temperatures. In the case of cell membrane quantum criticality could among other things make possible the kicking of the large $\hbar$ BCS type Cooper pairs between lipid layers of cell membrane. If so, neurons would be quantum critical only during nerve pulse generation.

   One can consider also alternative explanation. 50 meV is not much higher than 41 meV so that it could relate to the $\epsilon = 0 \to 1$ transition. Recoil effects are negligible. Perhaps $m = 1$ rotational excitation of electron of

2e system residing at the same flux tube and having energy $E = 9$ meV is in question. This excitation would receive the spin of photon. The energy scale of electronic rotational excitations is $\hbar^2/2m_eL^2(149) \sim 8.4$ meV if the radius of the flux tube is $L(149)$.

To sum up, the model allows to understand the four energies assuming natural values for adjustable parameters and predicts that $k = 151$ corresponds to stable Cooper pairs. It seems that the model could apply to a large class of quantum critical super-conductors and scaled up electrons might be involved with all condensed matter phenomena involving stripes.

3.3.4 Model for the resonance in neutron scattering

The resonance in neutron scattering is usually understood as a resonance in the scattering from the modification of the lattice induced by the formation of stripes and this scattering gives the crucial information about cross-like structure of Fermi surface of holes suggesting crossed stripes. One can also consider the possibility that the scattering is on exotic Cooper pairs which could always accompany stripes but as such need not give rise to super-conductivity or not even conductivity unless they are in quantum critical state.

Consider now the TGD based model for neutron scattering based on the proposed model for Cooper pairs.

1. Neutrons couple naturally to the magnetic field accompanying color magnetic field at the space-time sheet of Cooper pair by magnetic moment coupling. As found, $E_w = 41$ meV can be interpreted as the energy needed to induce the $\epsilon = 0 \to 1$ transition. Spin flip necessarily occurs if the electron is kicked between the vertical flux tubes.

2. Resonance would result from the coherent coupling to the wormhole BE condensate making scattering rate proportional to N^2, where N denotes the number of wormhole contacts, which is actually identical with the total number of super conducting electrons. Therefore the prediction of the TGD based model is very similar to the prediction of [34]. The absence of the resonance above critical temperature suggests that exotic Cooper pairs are not present above T_c. The presence of quantum criticality also above T_c suggests that Cooper pairs decay to wormholy space-time sheets containing single electron plus wormholy pion $u\overline{d}$ responsible for the ordinary conductivity. The transition is possible also for these space-time sheets but they do not form Bose-Einstein condensate so that the resonance in neutron scattering is predicted to be much weaker for temperatures above the critical temperature. For overcritical doping the resonance should be absent if exotic Cooper pairs are possible only at the boundaries of two phases disappearing at critical doping.

3. The momentum transfer associated with the resonance is located around the momentum $(\pi/a, \pi/a)$ in resiprocal lattice [46], where a denotes the

length for the side of the lattice cell. The only possible conclusion is that in the scattering neutron momentum is transferred to the lattice whereas the remaining small momentum is transferred to the momentum of wormhole BE condensate. Thus the situation is analogous to that occurring in Mössbauer effect.

3.3.5 What is the origin of picosecond time scale

The model should also predict correctly the picosecond and 1-10 nm length scales. Quantum criticality suggests that picosecond time scale relates directly to the 10 nm length scale via p-adic length scale hypothesis. $L(151) = 10$ nm defining the size for color flux tubes containing electrons of Cooper pair and lower limit for the distance between predicted super-stripes would correspond to a p-adic time scale $T(151) \sim 10^{-16}/3$ seconds for ordinary Planck constant. For $\hbar = 2^{22}\hbar_0$ this time scale would be scaled up to about $.15n$ picoseconds. This kind of length scale corresponds for electron to $n_F = 2^{22}$ rather than $n_F = 2^{11}$. One could however argue that by the very definition of quantum quantum criticality several values of n_F must be involved. The quantum model of EEG indeed assumes this kind of hierarchy. Note that $n_F = 3 \times 2^{12}$ would give picosecond scale as also (157).

Just for fun one can also consider the possibility that this time scale is due to the large $\hbar$ phase for nuclei and hadrons. Large $\hbar$ for nuclei and quarks would means gigantic Compton lengths and makes possible macroscopic quantum phase competing with ordinary phase. If one accepts TGD based model for atomic nuclei where $k = 129$ corresponds to the size of the magnetic body of ordinary nuclei [F8], the super-stripes could involve also the color magnetic bodies of dark hadrons. The size of color magnetic body for ordinary hadrons is $L(k_{eff} = 107 + 22 = 129)$ and therefore $L(k_{eff} = 129 + 22 = 151)$ for dark hadrons. This of course forces the question whether the nuclei along stripes correspond to dark nuclei. Large $\hbar$ phase for hadrons means also scaling up of the basic purely hadronic time scales. Notice that neutral pion lifetime $\sim 2 \times 10^{-16}$ seconds would be scaled up by a factor 2^{11} to .2 picoseconds.

3.3.6 Why copper and what about other elements?

The properties of copper are somehow crucial for high T_c superconductivity since cuprates are the only known high T_c superconductors. Copper corresponds to $3d^{10}4s$ ground state configuration with one valence electron. This encourages to think that the doping by holes needed to achieve superconductivity induces the dropping of these electrons to $k = 151$ space-time sheets and gives rise to Cooper pairs.

More generally, elements having one electron in s state plus full electronic shells are good candidates for doped high T_c superconductors. If the atom in question is also a boson the formation of atomic Bose-Einstein condensates at Cooper pair space-time sheets is favored. Superfluid would be in question. Thus elements with odd value of A and Z possessing full shells plus single s

wave valence electron are of special interest. The six stable elements satisfying these conditions are ^{5}Li, ^{39}K, ^{63}Cu, ^{85}Rb, ^{133}Cs, and ^{197}Au. Partially dark Au for which dark nuclei form a superfluid could correspond to what Hudson calls White Gold [116] and the model for high T_c superconductivity indeed explains the properties of White Gold.

3.4 Speculations

3.4.1 21-Micrometer mystery

21 micrometer radiation from certain red giant stars have perplexed astronomers for more than a decade. Emission forms a wide band (with width about 4 micrometers) in the infrared spectrum which suggests that it comes form a large complex molecule or a solid or simple molecules found around starts. Small molecules are ruled out since they produce narrow emission lines. The feature can be only observed in very precise evolutionary state, in the transition between red giant phase and planetary nebular state, in which star blows off dust that is rich in carbon compounds. There is no generally accepted explanation for 21-micrometer radiation.

One can consider several explanations based on p-adic length scale hypothesis and some explanations might relate to the wormhole based superconductivity.

1. 21 micrometers corresponds to the photon energy of 59 meV which is quite near to the zero point point kinetic energy 61.5 meV of proton Cooper pair at $k = 139$ space-time sheet estimated from the formula

$$\Delta E(2m_p, 139) = \frac{1}{2}\frac{\pi^2}{(2m_p)L(169)^2} = \frac{1}{8}\Delta E(m_p, 137) \simeq 61.5\ meV \quad .$$

   Here the binding energy of the Cooper pair tending to reduce this estimate is neglected, and this estimate makes sense only apart from a numerical factor of order unity. This energy is liberated when a Cooper pair of protons at $k = 139$ space-time sheet drops to the magnetic flux tube of Earth's magnetic field (or some other sufficiently large space-time sheet). This energy is rather near to the threshold value about 55 meV of the membrane potential. This observation and the presence of the carbon compounds leads to ask whether bio-superconductors and perhaps even some primitive forms of life might be involved.

2. 21 micrometer radiation could also result when electrons at $k = 151$ space-time sheet drop to a large enough space-time sheet and liberate their zero point kinetic energy. Scaling argument gives for the zero point kinetic energy of electron at $k = 151$ space-time sheet the value $\Delta(e, 151) \simeq 57.5$ meV which is also quite near to the observed value. If electron is bound to wormhole with quantum numbers of $\overline{d}$ Coulombic binding energy changes the situation.

3. A possible explanation is as radiation associated with the transition to high T_c super conducting phase. There are two sources of photons. Radiation could perhaps result from the de-excitations of wormhole BE condensate by photon emission. $\lambda = 20.48$ micrometers is precisely what one expects if the space-time sheet corresponds to $p \simeq 2^k$, $k = 173$ and assumes that excitation energies are given as multiples of $E_w(k) = 2\pi/L(k)$. This predicts excitation energy $E_w(173) \simeq 61.5$ meV. Unfortunately, this radiation should correspond to a sharp emission line and cannot explain the wide spectrum.

3.4.2 Ionic high T_c superconductivity and high T_c super-fluidity

The model of electronic superconductivity generalizes to the case of fermionic ions in almost trivial manner. The stability condition determining the p-adic length scale in question is obtained by replacing electron mass with the mass Am_p of ion and electron charge with the charge Ze of the ion. The expression of binding energy as sum of kinetic energy and Coulombic interaction energy has the general form

$$T_e + V_{ee} + V_{eq} = \frac{a_e}{L^2(k)} - \frac{b_e}{L(k)} \ , \tag{21}$$

and gives maximum binding energy for

$$L = \frac{2a_e}{b_e} \simeq L(151) \ . \tag{22}$$

The replacement of electrons with ions of charge Z induces the replacements

$$\begin{aligned} a_e &\rightarrow \frac{m_e}{Am_p} a_e \ , \\ b_e &\rightarrow Z^2 b_e \ , \\ L &\rightarrow \frac{m_e}{AZ^2 m_p} L_e \simeq \frac{1}{AZ^2} L(129) \ . \end{aligned} \tag{23}$$

This scale would be too short for ordinary value of $\hbar$ but if the nuclei are in large $\hbar$ phase, L is scaled up by a factor $\simeq n \times 2^{11}$ to $L(k_{eff}) = nL(k+22)$. This gives

$$L(k) \simeq \frac{n}{AZ^2} L(151) \ . \tag{24}$$

This length scale is above $L(137)$ for $AZ^2 < 2^7 n = 128n$: $n = 3$ allows all physical values of A. If $L(135)$ is taken as lower bound, one has $AZ^2 < 2^9 n$ and $n = 1$ is enough.

Second constraint comes from the requirement that the gap temperature defined by the stability against transition $k \to k-2$ is above room temperature.

$$3 \times \frac{\pi^2\hbar^2}{2Am_pL^2(k)} \simeq 2^{-k+137}\frac{.5}{A} \quad \text{eV} \geq T_{room} \simeq .03 \quad \text{eV} \quad . \tag{25}$$

Since the critical temperature scales as zero point kinetic energy, it is scaled down by a factor m_e/Am_p. $k \geq 137$ would give $A \leq 16$, $k = 135$ would give $A \leq 64$, and $k = 131$ allows all values of A.

The Bose-Einstein condensates of bosonic atoms giving rise to high T_c super fluidity are also possible in principle. The mechanism would be the dropping of atoms to the space-time sheets of electronic Cooper pairs. Thermal stability is achieved if nuclei are in doubly dark nuclear phase and electrons correspond to large $\hbar$ phase. Electronic Cooper pairs would correspond to $k_{eff} = 151 + 22 = 173$ space-time sheets with size about 20 μm. This is also the size scale of the Bohr radius of dark atoms [J6]. The claimed properties of so called ORMEs [116] make them a possible candidate for this kind of phase.

3.4.3 Are living systems high T_c superconductors?

The idea about cells and axons as superconductors has been one of the main driving forces in development of the vision about many-sheeted space-time. Despite this the realization that the supra currents in high T_c superconductors flow along structure similar to axon and having same crucial length scales came as a surprise. Axonal radius which is typically of order $r = .5$ μm. $\lambda = 2^{11}$ would predict $r = .2$ μm. The fact that water is liquid could explain why the radius differs from that predicted in case of high T_c superconductors.

Interestingly, Cu is one of the biologically most important trace elements [37]. For instance, copper is found in a variety of enzymes, including the copper centers of cytochrome c-oxidase, the Cu-Zn containing enzyme superoxide dismutase, and copper is the central metal in the oxygen carrying pigment hemocyanin. The blood of the horseshoe crab, Limulus polyphemus uses copper rather than iron for oxygen transport. Hence there are excellent reasons to ask whether living matter might be able to build high T_c superconductors based on copper oxide.

3.4.4 Neuronal axon as a geometric model for current carrying "rivers"

Neuronal axons, which are bounded by cell membranes of thickness $L(151)$ consisting of two lipid layers of thickness $L(149)$ are high T_c superconductors (this was not the starting point but something which popped out naturally). The interior of this structure is in large $\hbar$ nuclear phase, which is partially dark. Since the thickness of the tube should be smaller than the quantum size of the dark nuclei, a lower limit for the the radius r of the corresponding nuclear space-time sheets is obtained by scaling up the weak length scale $L_w(113) =$

$2^{(11-89)/2}L_w(89)$ defined by W boson Compton length by a factor 2^{22} to doubly dark weak length scale $L_w = 2^{22}L_w(113) = .2$ μm.

These flux tubes with radius $r > L_w$ define "rivers" along which conduction electrons and various kinds of Cooper pairs flow. Scaled up electrons have size $L(k_{eff} = 149)$ corresponding to 5 nm, the thickness of the lipid layer of cell membrane. The observed quantum fluctuating stripes of length 1-10 nm might relate very closely to scaled up electrons with Compton length 5 nm, perhaps actually representing zoomed up electrons!

According to the model of dark Cooper pairs the $k = 149$ flux tubes at which electrons are condensed should be hollow. What comes in mind first is that a cylinder with radius $L(149)$ is in question having a hollow interior with say atomic radius.

The original assumption that exotic *resp.* BCS type Cooper pairs reside at boundaries *resp.* interior of the super-conducting rivulet. It would however seem that the most natural option is that the hollow cylindrical shells carry all supra currents and there are no Cooper pairs in the interior. If exotic Cooper pairs reside only at the boundary of the rivulet or the Cooper pairs at boundary remain critical against exotic-BCS transition also below T_c, the time dependent fluctuations of the shapes of stripes accompanying high T_c super-conductivity can be understood as being induced by the fluctuations of membrane like structures. Quantum criticality at some part of the boundary is necessary in order to transform ordinary electron currents to super currents at the ends of rivulets. In biology this quantum criticality would correspond to that of cell membrane.

4 Models for ionic superconductivity and topological condensation at the magnetic flux quanta of endogenous magnetic field

In this section the model for ionic superconductivity is constructed as a straightforward generalization of the model of high T_c electronic superconductivity: the basic prediction is that only ions with $A < 4$ (in practice protons) can form stable Cooper pairs at room temperature. There is however a loophole 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 be actually exotic ions of this kind having different mass number and be able to form Bose-Einstein condensates. This is required by the recent model for nerve pulse [M2]. The prediction can be tested.

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 based on Cooper pairs

The model of ionic super-conductivity is a direct generalization of corresponding model for high T_c electronic super conductivity.

1. Electron is topologically condensed at a cylindrical space-time sheets of radius $L(k = 149) = 5$ nm and length $L(151) = 10$ nm and carrying magnetic monopole flux flowing through the wormhole throat at the upper end of the cylindrical sheet to the larger space-time sheet and returning back through the throat at the lower end of the sheet. Magnetic monopole flux made possible by the topology of CP_2 is necessary in order to have spin 1 Cooper pairs.

2. The two causal horizons associated with each wormhole contact carry quantum numbers of quark and antiquark and the charges of quark and antiquark at electron space-time sheet sum up to the negative of electron charge. The two flux tubes of this kind are connected by color bonds such that the state does not reduce to a product of color singlets. Hence color confinement is responsible for the formation of Cooper pair.

3. The requirement that the binding energy is maximum as a function of p-adic length scale implies that $k = 151$ corresponds to the length of the electronic flux tube and $k = 149$ to its radius.

Exactly the same mechanism works also in the case of ions and the only differences come from the different mass and charge of ion.

1. The weak length scale $L_w = .2$ μm associated with doubly dark $k = 113$ weak bosons gives an upper bound for the size of the Cooper pair. The requirement that the binding energy is minimum forces this length for the Cooper pair if one assumes that the diameter of ionic flux tube equals to its length.

2. For proton regarded as a particle in 1-D box the scale of excitation energy inside flux tube is $\Delta E \sim 3\pi^2\hbar^2/2m_pL_w^2 = .31$ eV for $\hbar = 2^{11}\hbar_0$ and safely above the maximum photon energy $E_{th} = 2.882T = .086$ eV of black body radiation at room temperature $T = 300$ K. For $A \geq 4$ nuclei this energy scale is below E_{th} ($A = 4$ gives $E = .078$ eV). Thus it would seem that only protonic Cooper pairs are relevant for living systems at $k_d = 1$ level of dark matter hierarchy. For $^7Li_+$ ion this energy corresponds to .04 eV. One cannot exclude the possibility that for effectively 2- or 1-D systems lithium Cooper pairs might be marginally stable. In the case of electronic Cooper pairs one has $\Delta E \sim 3 = .06$ eV ($E_{th} = \Delta E$ corresponds to $T = 219$ K) so that thermal stability criterion is marginally satisfied at room temperature.

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 [F9] 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. The table below 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_-^{++} tells that there is double electronic ionization and electron shell of Argon as usual but that one color bond is negatively charged.

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

(26)

$f_c(K+)$ 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 Model for Bose-Einstein condensation in endogenous magnetic field

The effects of ELF em fields on living matter suggest that quantal cyclotron transitions are involved. This does not conform with intuitive expectations since cyclotron energy scale is ridiculously as compared to the thermal energy at room temperature.

The earlier model based on ordinary $\hbar$ assumed thermal isolation between space-time sheets and that large space-time sheets are cold so that BE condensates are possible. Thermal stability in fractal sense requires that temperature scales like cyclotron energy as a function of p-adic length scale. Flux quantization implies that T scales like zero point kinetic energy: $T(k) \propto 1/L^2(k)$.

One can criticize the assumption about thermal isolation. Second criticism concerns the assumed flux quantization. The flux tubes of the endogenous magnetic field have radius which is at most $5L(167) = 8$ μm. This however suggests that ions and atoms can be in two states depending on whether they are condensed at magnetic flux tubes or not. In the absence of topological condensation to magnetic flux tubes no cyclotron transitions or spin flips should occur. The states in which ions do not respond to magnetic field have not been however observed. Usually it is assumed that no flux quantization occurs in macroscopic length scales but this assumption is in conflict with the idea that there are no preferred length scales. The scaling up of flux quantum by scaling of $\hbar$ could resolve this problem.

4.3.1 A model for the condensation of ordinary ion to dark magnetic flux tube

One particular set of preferred values of $\hbar_{eff} = n_a/n_b$ suggested by the model of living matter is as powers of $\lambda = 2^{11}$. Dark ions at space-time sheets having $(n_a = \lambda^k, n_b = 1)$, $k > 1$, are thermally unstable at room temperature since the atomic energy scale would be $\lambda^{-k}E_0$. The only possibility is that ion itself has small enough a value of n_a/n_b. The simplest possibility is $(n_a = 1, n_b = 1)$.

The next question concerns the magnetic interaction between ion and dark magnetic flux tube. The magnetic flux from the dark flux quantum must be feeded to the space-time sheet of ion and return back. This is indeed possible since it is M^4_+ projection which is zero-dimensional and corresponds to the tip of M^4_+ at the 2-surface which corresponds to parton just intermediate between two sectors. The 2-dimensionality of CP_2 projection allows non-vanishing magnetic flux. That magnetic flux cannot flow between sectors with different value of n_b might relate to Meissner effect. If so, the values of n_b for super-conductor and its environment would be different.

Since n_a sheets fuse to single one at the leakage point, the magnetic flux feeded to the ordinary space-time sheet of ion is n_a-fold so that cyclotron energy is n_a-fold too. One can equally well consider the situation also by assuming that the magnetic flux of ion is shared by the $N(G_a)$ flux sheets of the dark magnetic field and returns back to ion. The total magnetic interaction energy summed over the $N(G_a)$ identical G_a-related sheets is scaled up by n_a since the value of Planck constant is n_a time larger.

If the dark magnetic flux sheets with $k > 1$ contain nuclei, they form a fully ionized plasma at room temperature, and have cyclotron energies which are Z/A times the cyclotron energy of proton. For $B = .2$ Gauss this gives $f_c = (2Z/A)(f_p/2) = (2Z/A) \times 150$ Hz.

4.3.2 Why the endogenous magnetic field corresponds to .2 Gauss?

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. The applications to living matter suggests that the basic hierarchy corresponds to a hierarchy of Planck constants coming as $\hbar_{eff}(k) = \lambda^k(p)\hbar_0$, $\lambda = 2^{11}$ for $p = 2^{127-1}$, $k = 0, 1, 2, ...$ Each p-adic length scale corresponds to this kind of hierarchy. Number theoretical arguments suggest a general formula for the allowed values of λ [C7] as $\lambda = n$ where n characterizes the quantum phase $q = exp(i\pi/n)$ characterizing Jones inclusion [C6]. The values of n for which quantum phase is expressible in terms of squared roots 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 $h_0 \to h = nh_0$ in the transition increasing Planck constant: this is achieved by scalings $L(k) \to nL(k)$ and $B \to B/n$.

$B_{end} = .2 = 2B_E/5$ with $k = 169$, $\hbar = 5\hbar_0$, with flux tubes of radius 25 μm carrying flux $2h_5$ is the most natural option since gives a direct connection with the Earth's magnetic field. Furthermore, the model for EEG forces to assume that also the presence of the magnetic field $B_{end}/2$ 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 $B_n = 4cos^2(\pi/n)$ equal to Golden Mean [E9].

For a couple of years after writing this I realized that the value of B_{end} could be understood in much more deeper level. The secondary p-adic length scale associated with Mersenne prime M_{127} corresponds to a time scale of .1 seconds, the fundamental biorhythm. M_{127} is the largest not completely super-astronomical p-adic length scale corresponding to Mersenne prime and can be assigned to both electron and gravitons and perhaps also exotic scaled variants of quarks and neutrino. This led for many years ago to the idea that memetic code corresponds to M_{127} with the duration of memetic codon equal to .1 seconds and containing 126 bits of equal length.

The latest step in the progress of understanding the value of B_{end} relates to the understanding of how p-adic length scale hypothesis emerges from quantum TGD: this has been already explained in the introduction. The amazing prediction is that one can assign to elementary particle secondary p-adic time scale as a fundamental time scale. It correspond to the temporal duration of the particle space-time time sheet carrying positive and negative energy states at its future and past boundaries. In the case of single particle state these states correspond particle and its negative energy variant. In the general case the in-

terpretation for the detection of zero energy state is as a detection of initial and final states of particle reaction. Secondary p-adic time scale would be a concrete signature of zero energy ontology. The fundamental role of .1 seconds in biology and neuroscience could be interpreted in terms of the key role of Bose-Einstein condensates of electronic Cooper pairs. It would be rather natural for the cyclotron frequencies of biologically important ions to be as near as possible to 10 Hz. This would dictate the value of endogenous magnetic field to $B_{end} \simeq .2$ Gauss. If each ionic Bose-Einstein condensate lives at its own magnetic flux tubes, it is possible to fine tune the value of B_{end} to achieve an exact resonance.

4.3.3 How to identify the personal magnetic body?

The notion of magnetic body is central in the TGD inspired theory of living matter. Every system possesses magnetic body. If EEG corresponds to the purely personal aspects of consciousness, the magnetic body associated with human body should be of order Earth size. This however raises the question about how to distinguish between the magnetic bodies of Earth and of human body. As a matter fact, this problem turned out to be a pseudo problem due to calculational error. The value of the endogenous magnetic field is $B = .2$ Gauss from experiments of Blackman and others and corresponds to p-adic length scale $L(169)$ and $\hbar = 5\hbar_0$ level in dark matter hierarchy carrying two flux quanta h_5 whereas Earth's magnetic field would correspond to $L(169)$ and $n = 1$. What is nice is that $n = 5$ is the minimal value of n making universal topological quantum computation possible [E9].

One can argue that it is the neuronal time scale of millisecond rather than EEG time scale which serves as a correlate for the conscious experiences assignable solely to our biological body and that EEG is associated with the social aspects of our behavior. The problem with this argument is that our conscious experience contains contributions from much longer time scales than millisecond. The following argument based on a simple model for magnetic flux quanta allows to discuss this problem more quantitatively.

There are several manners to achieve quantization of magnetic flux with dynamical $\hbar$.

1. One possibility is that the area S of flux quantum scales as $\hbar^2$. In this case flux quantization implies that B and cyclotron frequency scale as $1/\hbar$ whereas cyclotron energy is invariant under the scaling of $\hbar$.

2. Second possibility is that the value of magnetic field remains invariant and S scales as $\hbar$. This is especially natural when flux quanta are magnetic flux walls. In this case cyclotron frequencies remain invariant but cyclotron energy scales as $\hbar$. The considerations of this chapter provide support for both quantizations in living matter.

For the latter option one can consider both tubular and sheet like flux quanta.

1. For tubular flux quanta $k_d = 4$ level of dark matter hierarchy the radii of tubular flux quanta would be about $2^{22} \times L(169) = L(169+44 = 213) = 20$

m for the Earth's magnetic field B_E. For the endogenous magnetic field $B_{end} = .2$ Gauss the radii of fundamental flux tubes would be $5L(169)$, the size of a large neuron. Using the above described identifications the radii of flux tubes would be scaled up by a factor 5 to about $2^{22} \times 5 \times L(169) = 100$ m. This length scale would define the size scale for the quantum coherence regions of the Bose-Einstein condensates of bosonic ions. This scale is enough to guarantee that the behavior of ions in B_{end} is consistent with the model based on single-sheeted space-time.

2. For $B_{end} = .2$ Gauss one can consider flux sheets with a total transversal length $5 \times L(169 + 4 \times 22) = 5L(257) = 4 \times 10^5$ km, which corresponds to about 62 Earth radii. Strongly folded flux sheets of this thickness might be associated with living matter and connect their DNAs to single coherent structure. The photon frequency corresponding to the wavelength $5L(257)$ is 1 Hz and characterizes delta band. One can however argue that DNA thickness which happens to be $\simeq 5L(169)/\lambda \simeq 12.5$ nm, slightly above cell membrane thickness of 10 nm, defines a more natural thickness of the flux sheet. In this case the width of the flux sheet would be scaled up by a factor λ to 8.9×10^8 km about 1.4×10^5 Earth radii: note that the length scale of the plasma sheet at night side extending to about 1000 Earth radii. Let us refer to these alternatives as option I and II respectively.

The question is whether one can assign a convoluted flux sheet of this width to a single human body or brain. Suppose that the magnetic flux flows in head to tail direction so that the magnetic flux sheet arrives to the human body through a string of cortical neurons. This means that the flux quantum traverses neuronal nuclei such that they are arranged like text lines of a book page along the flux sheet. This structure could closely correlate with the organization of central nervous system and give rise to what might be called super genes.

The total length of DNA in single human cell is about one meter. The DNA of about 8×10^7 neurons (1.6×10^{10}) neutrons would be required for option I (II) *if the contribution of DNA length dominates the width.* The italics are absolutely essential here! If the number of cortical neurons in single layer is about 8×10^7 which corresponds roughly to an average neuron radius of 10^{-5} meters then the flux sheet should go through all neurons in the uppermost neuron layer for option I. This cannot be the case and $k_d = 4$ flux sheets must traverse through several organisms so that they necessarily correspond to collective aspects of consciousness: the mind of Mother Gaia. Also the estimate $\lambda^4 L(151) < L < \lambda^4 L(169)$ for the over all size L of scaled up dark variant of cell nucleus suggests that single magnetic flux sheet traverses cells of organisms in an area of size $L > 180$ km.

If one assumes that the text lines on flux sheet are fully written, a more realistic candidate for the personal magnetic body would correspond to $k_d = 3$ with $B = \lambda B_{end}$ to achieve thermal stability. 1 Hz DNA cyclotron band would for $Z = 2$ flux quantization scale up to kHz band possibly involved with neuronal synchrony and defining the time scale of the nerve pulse. Flux quantization

requires flux sheets with width scaled down by λ^{-2} to 40 km. This requires neuronal strings traversing at least 4×10^4 neuronal nuclei which the highly convoluted cortex can easily accommodate. If the personal magnetic body can be regarded as a fractally scaled up cell nucleus, the estimate 80 m $< L <$ 176 km for the size of the personal magnetic body emerges for $\lambda = 2^{11}$.

The fact is however that our consciousness involves contributions from much longer time scales than millisecond. This raises difficult questions about our identity. Do I correspond to a single flux quantum of B_{end} after all: could it be that only a small fraction of these flux sheets corresponds to neuronal DNA and the empty parts of text lines are waiting for the evolution of larger brain to be fully written? How much of the contents of my conscious experience is from my own biological body? Why my sensory experience is dictated by my this particular biological body and why I possess intentional control only over it.

4.3.4 The definition of the model

The new 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 value of $\hbar(k) = \lambda^{k_d}\hbar_0$, $\lambda = 2^{11}$.

1. There are several levels of dynamics. In topological condensation the internal dynamics of ions is unaffected and $\hbar$ has the ordinary value. The formation of Cooper pairs involves dynamics at $k_d = 1$ level of dark matter hierarchy. Also the dynamics of ionic Cooper pairs remains unaffected in the topological condensation to magnetic flux quanta obeying $k > 1$ dynamics.

2. Cyclotron energies scale as as λ^{k_d} so that for a sufficiently high value of k thermal stability of cyclotron states at room temperature is achieved. Spin interaction energy $\mu \cdot B \propto S \cdot B$ scales as $1/\hbar$ since four-momentum and angular momentum are by Poincare symmetry invariant under the scaling of $\hbar$ (the highly non-trivial implications of the invariance of angular momentum are discussed in [C6]). Hence spin interaction energy has the ordinary value. Unless thermal isolation is assumed, spin degrees of freedom are thermalized, and only cyclotron degrees of freedom can be quantum coherent. This is a testable prediction distinguishing between the new and old model.

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

practice only protons into consideration. Also bosonic molecular ions can suffer BE condensation.

4.3.5 Schumann resonances, EEG and large $k_d = 4$ level of dark matter hierarchy

The photon frequency corresponding to the wavelength $5 \times L(256)$ (size scale of magnetic flux quanta assignable to living matter) is 1.5 Hz and defines delta band. The corresponding energy is $E = .238$ eV which is above than the maximum photon energy $E_{th} = .085$ eV of black body radiation at T=300 K. The frequency $f = 10$ Hz, which corresponds to secondary p-adic length scale associated with Mersenne prime M_{127} characterizing electron, and defines fundamental biological rhythm, corresponds to $E = .67$ eV.

The nominal value 7.8 Hz of the lowest Schumann resonance frequency [19] corresponds to .52 eV which is in the range of energies assignable to the metabolic energy quantum. $A \leq 233Z$ corresponds to $f_{min} = 1.29$ Hz which corresponds to delta band. The higher Schumann frequencies 14, 20, 26, 33, 39, and 45 Hz correspond to energies .9, 1.3, 1.7, 2.2, 2.6, and 3.0 eV. The corresponding photon energies belong to infrared and visible range in the case of ordinary photons. The Schumann frequencies 26, 33, and 39 Hz correspond to red, green, and blue light.

These observations suggest that EEG corresponds to $k_d = 4$ space-time sheets and that EEG frequencies correspond to dark photon energies above the thermal energy at body temperature. The dominance of theta and delta bands during sleep state could be due to the fact that the EEG photons at these energies are not able to induce metabolic effects. The reported strong effects of the lowest Schumann resonance frequency on human brain could be interpreted in terms of a metabolic resonance. Lowest Schumann resonance could also serve as a biological clock synchronizing the behavior of living matter in Earth length scale. Higher Schumann resonance frequencies could define a global reference for the representation of visible colors.

4.3.6 Bose-Einstein condensates of bosonic ionized atoms

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

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

Table 1. 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.

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 [75]. 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 [20]. 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.

4.3.7 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 the following table 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.

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

Table 2. 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.

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 [19], 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 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 [19].

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 [77] 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 [77] 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 geo-electromagnetic fields.

4.3.8 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 $T^{(2)}_{M_{127}} = .1$ 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.

4.3.9 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 Magnetic genome, magnetic homeostasis, and magnetic circulation?

The view about the interaction of magnetic flux sheets with DNA leads to a rather far reaching vision about what genetic code really is. The notions of

magnetic homeostasis and magnetic circulation are also highly suggestive.

5.1 The new view about genetic code

The concrete realization of the personal magnetic body or actually hierarchy of them labelled by $k_d = 0, 1, ..., 7$ was already discussed in section discussing the difference between personal magnetic body and that of Earth. The cautious proposal was that the personal magnetic body corresponds to $k = 169$ and to $\hbar = 5\hbar_0$ for $\lambda = 1$ with $B_{end} = .2$ Gauss carrying two units $h_5 = nh$ of magnetic flux. In the simplest situation the flux sheets have thickness $5L(169) \simeq 25$ μm and width which scales as λ^{k_d}, $\lambda = 2^{11}$. If the folded flux sheet goes through genomes such single cell or neutron contributes a length $5L(169)$ to the flux sheet, the number of cells traversed is $N = \lambda^k \times 5L(169)/L(DNA) = 2.5 \times 10^{-5}\lambda^k \simeq 5 \times 2^{k-1} \times 10^{3k-5}$, where $L(DNA) \sim 1$ m is the estimate for the total length of human DNA strand inside genome.

k	2	3	4	5	6	7
N	105	2.1E+5	4.4E+8	9E+11	1.8E+15	3.8E+18

Table 3. The table gives a rough estimate for the number of neurons of radius 25 μm traversed by the folded magnetic flux sheets and assumed to contain 1 meter of DNA in the case that the density of genes along the flux sheet is maximal.

$k_d = 6$ would give a total width of about 1.8×10^{12} km, which could correspond to the size of magnetosphere of Sun. The number of neurons traversed would be about 2×10^15. $k_d = 7$ would give a total width of about 400 light years defining size scale for the galactic nucleus. The assignment of cosmic consciousness with crown chakra would be really well justified. This width of flux sheet would require that it traverses through about 4×10^{18} neuronal nuclei to be compared with the number $\sim 10^{12}$ of neurons in human brain. The cells of human body would not be enough in the case that the lines of text defined by gene sequences are not almost empty. For $k_d = 5$ the number of genomes traversed would be of order $N \sim 10^{12}$. The number of neurons in human brain is estimated to be $\sim 10^{12}$. For $k_d \geq 6$ also other cells or neurons in other organisms must be added to the necklace unless the text lines defined by genomes are almost empty.

For $k_d < 4$ level the cyclotron frequencies in $B_{end} = 0.2$ Gauss do not correspond to cyclotron energies above thermal threshold so that stronger magnetic fields associated with $k < 169$ are necessary if cyclotron energies are to be of biological significance. It would seem that $k_d = 3$ defines upper bound in this respect: in this case $L(151)$ corresponds to cyclotron energies above thermal threshold for $A \leq 55Z$.

Those for whom pictures about mitosis are familiar might have had the feeling that the chromosomes are indeed bound to threads and that division of a dipole magnetic field to two occurs during cell division. This encourages to

speculate about the possible implications of the proposed realization of magnetic bodies corresponding to $k_d \geq 3$ levels of dark matter hierarchy.

1. The flux tube with given value of k_d need not go through every gene. It is also possible that same gene topologically condenses at flux sheets characterized by several values of k_d. These assignments are in principle dynamical. The flux sheets would obviously define a functional hierarchy such that at each level quite different structures or functions are coded. A natural guess would be that dark genes at level k_d code structure and functions related to dark matter at level k_d. This increases dramatically the representative power of genome and would explain why the amount of human genome differs only little from that of much more primitive organisms such as wheat or fishes.

   The emergence of dark matter hierarchy would be the manner to make genes multi-functional and bring in a hierarchy of increasingly refined abstraction hierarchy. In vertebrates the really significant evolution would take place at this level. This also allows a new perspective to the mysterious introns, the 95 per cent portion of DNA christened as "junk DNA" by materialistic biologists, as a part of genome codes mostly for functions associated with dark matter levels and culture rather than biology.

2. For $k_d \geq 2$ single human genome with a total length ~ 1 m of DNA cannot correspond to entire width of the magnetic flux sheet which is about 40 km for $k_d = 3$. This means that the flux sheet must traverse through a large number of genes and bind them to single super gene (this would occur even in the case that the flux sheet is branched).

   These super genes would be very literally light highly convoluted pages of book containing sequences of nucleons as text lines. The pages of this book would be dynamical and the evolution of individual would presumably be like writing this enormous body book and expressing it in various manners. They would provide an exponentially explosive representational power and the relation of genome itself to super-genome would be like that of bit to a large collection of computer programs. This would also mean that brain would have use quantum computational capacity (for TGD based model for topological quantum computation see [E9]).

3. Even more dramatic generalization of genome can be considered. There is in principle no reason why magnetic flux sheets could not pass through several organisms so that kind of hyper-genes would result. These hyper-genes could make possible the emergence of complex social structures with individuals obeying rules making possible complex behavioral patterns. In this case there is practically no upper bound for k_d. Hyper genes could have introns as building blocks and could express themselves electromagnetically via memetic code as discussed in [L1]. Very probably hypergenome would be highly dynamical unlike the hardwired ordinary genome.

4. Super genome would distinguish between man and wheat whereas hyper genome would explain the difference between monkeys and men having almost identical genomes. A dramatic boost in the evolution of hyper-genome probably occurred when humans started to emigrate from Africa. The evolution of spoken language occurred in parallel with this evolution. The emergence of the written language as a direct projection of the pages of the genetic book to the external world meant also a great leap forward in this evolution and led to the development of art and science and complex social structures. One could even consider the possibility of explaining cultural diseases like the emergence of Nazi Germany and global market economy (to take an example nearer to us) as the emergence of collective conscious entity with pathological hyper genome.

5.2 Magnetic homeostasis and magnetic circulation?

The possible importance of the precise value of the local magnetic field for say memetic code [L1] suggests that living matter has learned to control local magnetic field inside magnetic flux tubes just as it controls salt level of biological water.

In particular, B_{end} could have slightly different values at different levels k_d of dark hierarchy (cyclotron energies can be above thermal threshold only for $k_d \geq 4$). Cell differentiation could lead to the differentiation of the local value of B_{end} and the value could vary even inside single cell nucleus, and be slightly different for genes characterized by different value of k_d (that is, topologically condensed at flux sheet with this value of k_d).

There is rather precise analogy with blood flow since both incompressible velocity field of blood and magnetic field are divergence-free: 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 from outside would only interfere with this control.

For instance, alpha peak drifts in Hz range and this could be due 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.

5.2.1 Magnetic circulation

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. Also Z^0 magnetic circulation system is plausible.

5.2.2 Temperature dependence of the local magnetic field strength

EEG frequencies are known to change with temperature [55]. The assumption that the thickness of the magnetic flux tubes depends on temperature implies that EEG frequency scale varies with temperature. One might think that this kind of mechanism could partially explain why a serious hibernation leads to a lower level of arousal. The results of Blackman [86] 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 is 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 from $k_d = 4$ magnetic body.

Circadial 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 observation that widely separated brain regions tend to fluctuate in unisono [54] is not easy to understand if one imagines brain as consisting of independent oscillators. If important EEG frequencies correspond to magnetic transition frequencies, the fluctuations can be understood as induced from fluctuations of the local magnetic field possibly induced by the organism itself.

5.2.3 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 [77] and confuse biological timekeeper mechanisms but it certainly cannot raise alpha band above 100 Hz. The resolution of the this objection is simple. The size of the volume in which artificially generated magnetic field prevails determines the value of k_d and p-adic length scale $L(k)$ in question. k_d is definitely smaller than $k_d = 4$ associated with the flux sheets corresponding to B_{end}. Secondly, the ability to perturb the magnetic field at $k_d = 4$ flux sheets associated with DNA would presumably require a refined technology. If organism has developed magnetic homeostasis, it tends to keep the magnetic

field constant inside the flux sheets just as cell tends to keep the salt concentration constant. Thirdly, if $B_{end} = .2$ Gauss indeed corresponds to $\hbar = 5\hbar_0$, the coupling to the variations of Earth's magnetic field might be rather weak. This would also resolve the problem posed by the fact that astronauts have survived in magnetic fields much weaker than the Earth's magnetic field.

Assuming that k_d is fixed, p-adic length scale hypothesis suggests that the increase of local field strength of flux quantum by a factor four would cause change of p-adic scale since $p \simeq 2^k$, $k = 167$ is the next p-adic length scale below $k = 169$: this scale is by a factor 2 shorter so that magnetic field scales up by a factor of 4. Of course, it could be also that the increase of the local magnetic field with strength defined macroscopically by flux per area might only tend to thicken the flux tubes or increase their volume density rather than increasing the value of the magnetic field inside flux tube.

5.3 Some remarks and questions

5.3.1 Synchronizing effect of Earth's magnetic field

Magnetic homeostasis and the deviation of B_{end} from B_E does not prevent the effects due to the variation of the Earth's magnetic field on human consciousness, and Earth's magnetic field could act as a grand synchronizer of biorhythms or even separate organisms.

The close correlation of various cycles of biological and brain activity, in particular sleep-wake cycle, with periodic circadial variations of the geomagnetic field [77], 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 [77]. Also Persinger has proposed that the modulations of Earth's magnetic field caused by geomagnetic perturbations have effect on human consciousness [92, 77]. 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 [93, 94, 95].

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-syncronization of biorhytms and that the synchorization of ELF biorhytms is coupled to ELF geomagnetic pulsations [77]. 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 [91] 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-rhytms 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 [114, 113] 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. The endogenous magnetic field $B_{end} = .2$ Gauss which is most important for the function of living matter is associated with the personal magnetic body and is not affected. This alone might explain why astronauts are able to survive.

2. Astronauts could draw the magnetic flux sheets connecting them to the magnetic body of Earth and possibly existing higher level magnetic bodies with them. Only $k_d = 4$ level might be affected since for $k_d > 4$ the length scale involved, which corresponds to height of ionosphere, is shorter the than the distance travelled.

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. The question is what happens for the possibly existing Josephson junction associated with 180 km thick layer composed of litosphere and connecting brain to magnetic body of Earth? Could the Josephson current run still now but from litosphere to the magnetic sheets to the brain of astronaut and back to the ionosphere? A long period in space might change the situation and this could relate to the strange experiences of astronauts. If the contribution of $k_d = 4$ level weakens it might happen that $k_d > 4$ levels with longer time scale begin to dominate the consciousness.

5. The experiences are also consistent with TGD based view about geometric time and possibility of geometric memories extending beyond the duration of individual life cycle. If one takes seriously the report about dinosaurs, which lived for $\sim 10^8$ years ago, $k_d = 9$ level which corresponds to Josephson period of 5.44×10^9 years, could have contributed to the conscious experience of astronauts.

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, might not be an accident. Surprisingly many magnetic transition frequencies for $B_{end} = .2$ Gauss happen to be near to Schumann resonance frequencies. During this period the weakening of B_E has reduced cyclotron frequency spectrum of heavy ions in Earth's magnetic field from the range $[f_{l,E}, f_{u,E}] = [7.5, 20]$ Hz range to the range $[f_{l,E}, f_{u,E}] = [3.75, 10]$ Hz.

B_{end} could have stayed constant through this period so that frequency interval would have remained $[f_{l,end}, f_{u,end}] = [1.5, 4]$ Hz for all the time. Interestingly, delta frequencies near 3 Hz, which correspond to a peak in the frequency spectrum of so called sferics associated with lightning activity [21], would have belonged to the endogenous range during the entire period in this case. The fast evolution might have related to the change of the character of the interaction between B_E and B_{end}: indeed $f_{l,E} = 3.75$ Hz is slightly above $f_{lu,end} = 4$ Hz. If B_{end}/B_E has been constant, then the cyclotron frequency interval for heavy ions in B_{end} would have reduced from 3-8 Hz to 1.5-4 Hz.

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 appreciably during this period but that the violent change of Earth's magnetic field induces dramatic effects on collective aspects of consciousness at $k_d = 4$ level as the findings of Callahan suggest.

5.3.2 What about spin flips?

In the original scenario based assuming that cold space-time sheets are dark and $\hbar$ has the ordinary value, also Larmor frequencies were important: effects of em fields in living matter at Larmor frequencies have not been however reported.

For some time I though that the Because spin is invariant under the scaling of $\hbar$ Larmor energy is negligible as compared to the cyclotron energy so that it seems that spin is thermalized in the most pessimistic scenario and spin does not play important role in the understanding of consciousness.

There is however a notable exception: cognitive neutrino pairs which correspond to wormhole contacts carrying quantum numbers of neutrino and antineutrino at their throats identified as light-like causal horizons. In condensed matter it is possible to achieve a situation in which cognitive neutrino pairs are created from vacuum and since they have zero energy the notion of thermalization does not make sense. If this heuristics is correct, the earlier quantum model for hearing and cognition can be saved and despite the dramatic modifications of basic assumptions makes essentially the same basic quantitative predictions.

5.3.3 What about Z^0 magnetic transitions?

The idea that Z^0 magnetic magnetic transitions might be relevant for biomatter have been discussed already earlier. The identification of the sources of long ranged classical weak fields as dark matter forces however a profound modification of the earlier picture.

The TGD based models for atomic nuclei [F8] and condensed matter [F10] suggest strongly that the dark variant of $k = 113$ copy of $k = 89$ electro-weak physics is essential for understanding of not only the anomalies of water but also the basic properties of condensed matter. Also other copies of electro-weak physics with arbitrarily small weak mass scale are implied by the fact that long ranged classical weak fields are unavoidable in TGD Universe. Also the scaled down copies of color physics with arbitrarily low mass scales for quarks are a basic prediction of TGD.

If classical Z^0 magnetic field is present and if nuclei possess anomalous weak charges due to the presence of color bonds with quark and antiquark at their ends carrying non-vanishing net weak charges coupling to $k = 113$ dark weak bosons, one must consider also Z^0 cyclotron frequencies given by

$$\begin{aligned} \Omega &= \frac{N(u\bar{d})}{A} \times Q_Z(u\bar{d}) \times \frac{g_Z B_Z}{eB} \times \Omega_p \ , \quad \Omega_p = \frac{eB}{m_p} \ , \\ Q_Z(u\bar{d}) &= \frac{1}{2} - sin^2(\theta_W) \ . \end{aligned} \tag{27}$$

Here $N(u\bar{d})$ is anomalous Z^0 charge of the nucleus due to weakly charged color bonds connecting nucleons with quark and antiquark at their ends using $u\bar{d}$ Z^0 charge $Q(u\bar{d})$ as unit. Ω_p is proton cyclotron frequency, which is about 300 Hz for $B = B_{end} = .2$ Gauss. The dependence on the Z^0 magnetic transition frequencies on the mass of nucleus is same as in the electromagnetic case.

The doubly dark weak bosons with weak length scale $L_w = 2^{22} L_w(113) = .2$ μm should be key actors in TGD based model of living matter. Since the quantization of magnetic flux uses $\hbar$ as unit the quantum of Z^0 flux over a given area is multiplied by a factor 2^{22} for doubly dark weak bosons. Also the

energy $\hbar\omega_c$ associated with the cyclotron frequency is multiplied by a factor 2^{22} so that energies are by a factor 2^{44} higher for cyclotron transitions in flux quantized Z^0 magnetic field than one might expect. In the case of dark quarks it would be natural to use $2(Q_Z(u\bar{d})$ as unit of charge in the quantization of magnetic flux so that the flux quantization reads $2Q_Z(u\bar{d})\int B_Z dA = n2^{22}\hbar 2\pi$.

Z^0 flux quanta with radius $L_w = .2$ μm are expected to be of special interest. Consider the field corresponding to single flux quantum in this case. Using the fact that $B_{end} = 2$ Gauss corresponds to a single quantum of flux through a disk of radius $5L(k = 168)$, one obtains that the Z^0 cyclotron frequency and energy in this case are given by

$$\begin{aligned} f_c(2^{22}\hbar(5), 168) &= 2^{22}\frac{N(u\bar{d})}{A} \times Q_Z(u\bar{d}) \times (\frac{5L(168)}{L_w})^2\omega_p(B_{end}) \\ &\simeq \frac{N(u\bar{d})}{A} \times 1.875 \ \ THz \ , \\ E_c(2^{22}\hbar) &= 2^{44}\frac{5}{\sqrt{2}}E_c(\hbar) \simeq \frac{N(u\bar{d})}{A} \times 2.5 \times 10^4 \ \ eV \ . \end{aligned} \tag{28}$$

Note that Ω_c and E_c do not depend on the unit of flux quantization. Cyclotron frequencies are in GHz range but energies in 10^4 eV range and corresponds to ordinary photon wavelength of about atomic length scale. In the earlier picture frequencies were in 10 Hz range. The energies involved are well above the thermal energy at room temperature. For the first level of dark matter hierarchy the frequency scale would be .9 GHz and energy scale 6 meV which is below the thermal energy at room temperature.

Also ordinary nuclei containing charged color bonds would couple to dark weak bosons with weak length scale having nominal value $L_w = 2^{11}L_w(113) = 1$ Angstrom. In this case Z^0 magnetic fields would have 2^{11} stronger strength that in previous case and cyclotron energies would be same.

6 Two models for the hierarchy of Josephson junctions

One can imagine two manners to realize the hierarchy of EEGs and Josephson junctions.

1. The original model was based on a too restricted view about the generalized imbedding space and led to a model of Josephson junctions assigned to a fractal hierarchy of cell membrane like structures with arbitrarily large thickness for the scaled up variant of cell membrane but possessing same membrane potential as ordinary cell membrane. This assumption is very strong and could quite well be unrealistic.

2. Few years later a further generalization of the imbedding space emerged allowing hierarchy of Josephson junctions assignable to cell membrane it-

self. This option looks much more realistic and will be discussed after a brief summary of the generalization of the notion imbedding space. The generalization of the imbedding space is discussed in more detail in Appendix.

6.1 Generalization of the notion of imbedding space

Quite generally, the hierarchy of Planck constant is realized by generalizing the notion of imbedding space such that one has a book like structure with various almost-copies of imbedding space glued together like pages of book. Each page of book correspond to a particular level of dark matter hierarchy and darkness means that there are no Feynman diagrams in which particles with different value of Planck constant would appear. The interactions between different levels of hierarchy involve the transfer of the particles mediating the interaction between different pages of the book. Physically this means a phase transition changing the value of Planck constant assignable to the particle so that particle's quantum size is scaled. At classical level the interactions correspond to the leakage of magnetic and electric fluxes and radiation fields between different pages of the book.

6.1.1 Original view about generalized imbedding space does not allow understanding of quantum Hall effect

The original generalization of the imbedding space was too restricted and the belief that the proposed generalization of the imbedding space could explain naturally phenomena like quantum Hall effect involving fractionization of quantum numbers like spin and charge turned out to be wrong. The idea was that a given page of the book like structure would correspond to an orbifold obtained from $H = M^4 \times CP_2$ by identifying the points of H obtained from each other by the action of group $G_a \times G_b$, where the factors act in M^4 and CP_2 degrees of freedom. As a matter fact, this identification implies just the opposite of fractionization if these quantum numbers are assigned with the symmetries of the imbedding space. For instance, quantization unit for orbital angular momentum becomes n_a where Z_{n_a} is the maximal cyclic subgroup of G_a.

One can however imagine of obtaining fractionization at the level of imbedding space for space-time sheets, which are analogous to multi-sheeted Riemann surfaces (say Riemann surfaces associated with $z^{1/n}$ since the rotation by 2π understood as a homotopy of M^4 lifted to the space-time sheet is a non-closed curve. Continuity requirement indeed allows fractionization of the orbital quantum numbers and color in this kind of situation.

6.1.2 Extension of imbedding space by allowing coverings

This means an extension of the imbedding space by allowing also G_a *resp.* G_b-fold coverings of $\hat{M}^2 = M^4 \backslash M^2$ *resp.* $\hat{CP}_2 = CP_2 \backslash S^2$, where M^2 corresponds

to 2-D Minkowski space defined by the fixing of rest frame and direction of quantization axis of angular momentum and S^2 to a homologically trivial geodesic sphere of CP_2 which corresponds to a particular choice of group $SO(3) \subset SU(3)$ and thus fixing of quantization axes of color isospin. The surfaces $X^4 \subset M^4 \times S^2$ are vacuum extremals as required by internal consistency of the theory. The leakage between different pages of book occurs via manifolds $M^4 \times S^2$ and $M^2 \times CP_2$ which correspond to quantum criticality. The extreme form of quantum criticality corresponds to leakage through $M^2 \times S^2$.

The book has four kinds of pages:

1) $[\hat{M}^4/G_a] \times [\hat{CP}_2/G_b]$ with Planck constant $\hbar/\hbar_0 = n_a/n_b$: n_i is the order of maximal cyclic subgroup of G_i. Only these pages were included in the original "book": the problem concerning biological applications is that large values of Planck constant require high rotational symmetries;

2) $[\hat{M}^4$" $\times$ "$G_a] \times [\hat{CP}_2/G_b]$ with $\hbar/\hbar_0 = 1/(n_a n_b)$: " $\times$ "G_i refers to G_i covering. Note that Planck constant is always smaller than its standard value $\hbar_0$ ($n_a = n_b = 1$) in this case implying for instance that the binding energy scale of hydrogen atom is scaled up;

3) $[\hat{M}^4$" $\times$ "$G_a] \times [\hat{CP}_2$" $\times$ "$G_b]$ with $\hbar/\hbar_0 = n_b/n_a$;

4) $[\hat{M}^4/G_a] \times [\hat{CP}_2$" $\times$ "$G_b]$ with $\hbar/\hbar_0 = n_a n_b$; note that in this case the Planck constant is maximal.

6.1.3 Maximimation of Planck constant in quantum control and communication in living matter

The pages of type 4) are the most promising candidates concerning the understanding of living matter, at least the quantum control of living matter.

1. G_a symmetry is implied in M^4 degrees of freedom since the restriction to the orbifold $\hat{M}^4/G_a$ is equivalent to the G_a-invariance of quantum states. Molecular rotational symmetries correspond typically to small groups G_a.

2. $G_a = Z_n$, $n = 5, 6$ are favored for molecules containing aromatic cycles. Also genuinely 3-dimensional tedrahedral, octahedral, and icosahedral symmetries appear in living matter. In this kind of situation one could have for given G_a the hierarchy $n_b = 2^{11k}$) giving rise to large values of Planck constant. This hierarchy might be realized both at the level of DNA and cell membrane.

3. Also the hierarchy of EEGs could correspond to this hierarchy and one could assume that cell membrane gives rise to the entire hierarchy. Also other powers of 2 could occur in the hierarchy.

6.2 The new model for the hierarchy of Josephson junctions

The original model for EEG led was based on the generalization of imbedding space obtained by gluing together almost-copies of imbedding space such that

copies where effectively orbifolds H/G $G = G_a \times G_b$ the product of discrete subgroups of rotational group SO(3) and $SO(3) \subset SU(3)$. The model forced the admittedly weird looking assumption that cellular Josephson junctions are accompanied by their fractally scaled up variants with cell membrane thickness 2^{11k}, $k = 0, 1, 2, ...$ with very precisely same value of electric field. This means quite a strong assumption about the dark matter hierarchy.

After few of years after developing the first version of the model the obvious questions are whether one could avoid such a strong assumption about dark matter hierarchy and whether one could assume that Josephson junctions in hierarchy have the same thickness defined by cell membrane thickness. This seems to be possible.

The further generalization of imbedding space by allowing G_a- *resp.* G_b-coverings of $M^4\backslash M^2$ *resp.* $CP_2\backslash S^2$ leads to a more general formula for Planck constant. If imbedding space corresponds to n_b-fold covering of $CP_2\backslash S^2$ then Planck constant is proportional to n_b. This means that besides n_a-fold symmetry in M^4 degrees of freedom also n_b-fold covering in CP_2 degrees of freedom makes possible to make Planck constant large.

This would suggest that cell membrane Josephson junctions for large values of Planck constant to n_b-fold CP_2-coverings of ordinary cell membrane Josephson junctions with electronic Cooper pairs at the sheets of covering. The value of Planck constant would be $n_a n_b$-fold for pages of type 4) discussed in previous subsection. If the thickness of Josephson junction is not changed one obtains only the scaling of photon wavelengths for a given photon energy.

Cyclotron frequency would remain invariant but Josephson frequency would be scaled down since one has $f_J = ZeV/\hbar$. This kind of slowing down of oscillation of the Josephson current should have interpretation in terms of the modified topology in CP_2 degrees of freedom. The simplest interpretation would be that covering means that oscillation corresponds to a closed orbit in CP_2 degrees of freedom which for n_b-fold covering closes only after n_b cycles. It seems that this option is the more realistic one.

6.2.1 p-Adic fractal hierarchy of Josephson junctions is possible also in the new model

The older model postulated a hierarchy of Josephson junctions which involved two hierarchies, dark matter hierarchy and p-adic hierarchy in a kind of resonance for living matter systems. The unrealistic looking assumption was that there exists a hierarchy of cell membrane like structures with increasing thickness scaled up by factor 2^{11k} acting as Josephson junctions and characterized by the same voltage as ordinary cell membrane.

In the new model the dark hierarchy of Josephson junctions is replaced with a hierarchy of layers of the onion-like magnetic body assignable to the ordinary cell membrane. It is of course still possible to have hierarchy of Josephson junctions at least in length scales regarded usually as biologically relevant. The voltage through the junction need not however be same as for the ordinary cell membrane anymore.

In particular, twin primes abundant in the p-adic length scale range assignable to living matter could define double layered structures acting as Josephson junctions.

$(k, k+2)$	$(137, 139)$	$(149, 151)$	$(167, 169 = 13^2)$	$(179, 181)$
$L(k)$	.78 A	5 nm	$2.5\mu m$	.32 mm
$(k, k+2)$	$(191, 193)$,	$(197, 199)$		
$L(k)$	1 cm	8 cm		

Table 4. Twin primes define especially interesting candidates for double membrane like structures defining Josephson junctions. Also included the pair $(137, 13^2 = 169)$ although $k = 169$ is not prime. The two largest scales could relate to structures appearing in brain.

6.2.2 An objection against the older model for the fractal hierarchy of Josephson junctions

There is a counter argument against the hierarchy of cell membrane like structures with a scaled up thickness coming as powers of $2^1 1$. The electric field involved with the higher levels of Josephson junction hierarchy is very weak: something like 10^{-7} V/m for lito-ionospheric Josephson junctions (of thickness about 176 km from the scaling of the cell membrane thickness by $\lambda^4 = 2^{44}$) which might be responsible for EEG. The electric field of the Earth at space-time sheets corresponding to ordinary matter is much stronger: about $10^2 - 10^4$ V/m at the surface of Earth but decreasing rapidly as ionosphere is approached being about .3 V/m at 30 km height. The estimate for the voltage between ionosphere and Earth surface is about 200 kV [22].

The many-sheeted variant of Faraday law implies that on order to have a voltage of order .08 V over lito-ionospheric Josephson junction at dark matter space-time sheet, the voltage over ionospheric cavity must be almost completely compensated by an opposite voltage over litosphere so that lito-ionospheric double layer could be seen as a pair of capacitor plates in a radial electric field of order 10^{-7} V/m generated by the charge density in sub-litospheric part of Earth. This condition requires fine-tuning and therefore looks unrealistic.

A natural distance scale in which the electric field is reduced would correspond to 10-20 km thick layer in which whether phenomena are present. The mirror image of this layer would be Earth's crust. The cell membrane counterpart would be a dipole layer like charge density between the lipid layers of the cell membrane. Note that the electric field at dark matter space-time can be constant. However, as far as Josephson junction is considered, it is only the net voltage what matters.

The new model for EEG implies fractal onion-like hierarchy of dark magnetic bodies assignable to cell membrane labelled by the values $\hbar/\hbar_0 = 2^{11k}$. As already noticed, the older model differed from the new one in that it predicts similar hierarchy of cell membrane like structures defining Josephson junctions with same membrane potential.

6.3 The two hierarchies of Josephson junctions and generalized EEGs

Two hierarchies are possible. One can have a p-adic hierarchy of Josephson junctions with an increasing thickness of the corresponding membrane like structure and to each membrane like structure one can assign a dark hierarchy of generalized EEGs corresponding to powers of 2^{11}.

6.3.1 The possibility of a p-adic hierarchy of membrane like structures accompanied by Josephson junctions

One can imagine the existence of fractally scaled up variants of cell membrane defining hierarchy of Josephson junctions possibly realized as magnetic flux tubes. The possible existence of this hierarchy is however not relevant for the model of EEG in its recent form.

The first hierarchy correspond to the p-adic length scales varying in the range of biologically relevant p-adic length scales $L(k)$ involving membrane like structures. Twin primes $(k, k+2)$ are good candidates here (Table 4). Second hierarchy corresponds to dark matter hierarchy for which length scales come in powers $2^{11k_d}L(k)$). The general prediction is that λ is power of two and $k = 11$ is favored value because it corresponds to a fundamental constant in TGD. There are also other arguments supporting the exactness of this value.

The original restriction to just these values of Planck constant is not required by the recent view about the hierarchy of Planck constants and might well be too restrictive. The hierarchy could involve also the Planck constants $2^{11k_d}n$, n small integer, possibly expressible in terms of Fermat primes. For instance, $n = 3$ with $k_d = 4$ would give 10 Hz EEG frequency for .08 eV resting potential.

Since 11 p-adic length scales combine naturally to form single block in this hierarchy, there is a strong temptation to assume that p-adic length scales $k = 151, 147, 163, 167, 169$ form the fundamental block. Same length scale can have interpretation as several different p-adic length scales belonging to different levels of dark hierarchy. This is expected to induce an interaction between various levels of dark matter hierarchy.

The size of cell nucleus varies in the range ($L(169) = 5\ \mu m, 2L(169) = 10\ \mu m$). This is consistent with the assumption that cell nucleus provides the fundamental representation for this block. This would mean that at least the multiply coiled magnetic flux quantum structures associated with DNA appear as fractally scaled up copies.

Each dark matter level corresponds to a block of p-adic length scales $L(k)$, $k = 151, ..., 169$. Also new length scales emerge at given level k_d and correspond to $L(k)$, $k > 169$. The dark copies of all these length scales are also present. Hence something genuinely new would emerge at each level.

6.3.2 Fractal hierarchy of magnetic bodies assignable to cell

Second hierarchy corresponds to a dark matter hierarchy involving powers 2^{11k} of given p-adic length scale assignable to biological membrane like structure.

The emergence of a genuinely new structure or function in evolution would correspond to the emergence of new level in this fractal hierarchy. Quantum criticality would be essential: phases corresponding k_d and $k_d + 1$ levels would compete at quantum criticality.

The flux sheet or tubes through cell membranes should integrate to larger structures at the higher levels of dark matter hierarchy implying the integration of sensory inputs from a large number of cells to single coherent input at higher levels of dark matter hierarchy. One can think two options: the sensory inputs from cell membranes are communicated directly to the magnetic body or via cell nuclei. The second option would require that the flux sheets or tubes starting from cell membrane traverse also the DNA.

1. $k_e = 0$ would correspond to cell nucleus since electronic and possible neutrino superconductivity made possible by scaled up variant of weak interactions can correspond to ordinary $\hbar$. One could assume for definiteness that the magnetic body involved as size scale of cell membrane thickness at this level but could also consider some larger size which is scaled up at higher levels of the hierarchy by the scaling factor 2^{k11}.

2. $k_d = 1$ would correspond to the emergence magnetic bodies with sizes below 4 cm. This size scale could be assigned to organs bounded by epithelial sheets (double cell layers) of thickness about 20 μm. Also in the new model these layers could define Josephson junctions but with some other voltage than that associated with the cell membrane.

3. $k_d = 2$ would correspond to layers of thickness 4 cm and structures with size smaller than 80 m. Obviously genuinely dark level is in question now. The layers of this Josephson junction could be assignable to left and right halves of central nervous system. The interpretation in terms of dark matter around the magnetic body of organs suggests also itself. $k_d = 3$ corresponds to the emergence of double layered dark matter structures of thickness 80 m and size scale below 160 km. Now dark matter condensed around magnetic bodies of magnetic bodies of organs could be in question.

4. $k_d = 4$ could correspond to the emergence of EEG assignable to flux sheets of personal magnetic body. The bilayered structure has thickness of 80+80 km and the analog of cell nucleus has minimum $512 \times 160 = 8$ Mm and corresponds to Earth size scale (Earth radius is 6.96 Mm).

It must be emphasized that also other values of k besides $k = 168$ with $n = 5$ can be considered. In particular, the values $k = 151, 157, 163, 167$ corresponding to Gaussian Mersennes are especially promising candidates for characterizing endogenous magnetic fields. The model of EEG in turn leads to the conclusion that also $k = 169$ with $n = 5$ must be present. The relevant length scales vary accordingly.

6.3.3 Dark hierarchy of EEGs

The dark hierarchy of Josephson junctions with fixed size characterized by a p-adic length scale most naturally assignable to a member of twin prime pair defining a fractal hierarchy of EEGs is the basic element of the model of generalized EEG.

1. Josephson junctions provide a representation of electric field as biological action induced by generalized EEG

Each junction has a background voltage over it. The basic hierarchy involves the p-adic length scales $L(k)$, $k = 151, ..., 169$. One could consider the possibility that not only $k = 151$ but all these length scales and also twin primes define their own Josephson junctions with their own values of Josephson potential. Note however that if the Josephson voltage behaves like $1/L_(k)$ - as the naive scaling would suggest - then Josephson energy $E_J = ZeV$ is below the thermal energy for $k > 151$.

Josephson current can be written as

$$J \propto sin[(2eVt + 2e \int V_1 dt)/\hbar] \ ,$$

where V corresponds to the background voltage analogous to resting potential of cell membrane and varies in rather narrow limits. $V_1(t)$ represents external perturbation.

The model for nerve pulse [M2] supports strongly that V actually corresponds to a propagating soliton sequence associated with Sine-Gordon equation. As described in the section about EEG, the situation is mathematically equivalent to a linear array of gravitational penduli coupling with each other and soliton sequence corresponds to a rotation of penduli with constant phase difference between neighbors so that a propagating wave would result. The analog of EEG would be associated also with ordinary cell membranes but the smaller value of $\hbar$ would imply that the frequencies involved are higher. Non-propagating EEG would accompany neuronal soma and possible propagating EEG waves with axons.

The frequency of V_1 is represented as a period of periodic multiplicative modulation of the V_0. J itself is not periodic. There is however a periodicity with a period $T = n/f$, where f is frequency of V_1 for $f_J = mf/n$. There are two interesting limits. For $f_J^1 = 2eV_1/2\pi\hbar \gg f_J$ amplitude V_1 is represented as frequency since in reasonable approximation frequencies $f_\pm = f_J \pm f_J^1$ dominate. Second limit corresponds to $f_J^1 \ll f_J$. In this case the dominating frequencies are $f_\pm = f_J \pm f$.

Josephson frequency would define a kind of drum beat whereas the frequencies associated with V_1 would represent the rest of the music. Josephson frequency $f_J = eV/2\pi\hbar$ indeed turns out to belong to the scaled up variant of delta band of EEG and thus defines the analog of drum beat and corresponds to a resonance frequency in delta band for the scaled up variants of EEG. Josephson frequency defines a candidate for the time unit in which the time scale of

memories and intentional action of the living system are measured.

The coherent photon state generated by J defines representation of V_1 as a generalized EEG and biological representations result when the photons interact with the living matter.

The reactions of the Josephson junctions corresponding to different p-adic length scales $k = 151, ..., 169$ (if really present!) to external electric field are different due to $V_1 \propto L(k) \propto 2^{(k-151)/2}$ proportionality and independence of V on k.

2. Thermodynamical considerations

Josephson energy does not depend on the level of dark matter hierarchy and is thus above thermal energy since this holds true in the case of cell membrane. From the resting potential whose nominal value is often taken to be for .08 V, f_J corresponds roughly to the energy .16 eV roughly twice the energy allowed by thermal stability. Thermal stability of drum beat would allow 140 °C temperature. The growth temperatures of thermophilic bacteria can be even higher than 100 °C.

Nerve pulse is generated when the potential drops to .05 eV: the corresponding Josephson energy is .01 eV which is above thermal threshold for $T \leq 70$ C. For organisms possessing no nervous systems, in particular bacteria, this constraint is not relevant. The energy $E = .1$ eV is twice the energy $E = .05$ eV, which is a universal transition energy of Cooper pairs of high T_c electronic super conductor [J1]. The generation of nerve pulse might involve these transitions.

3. Josephson frequencies

Resting potential corresponds to the Josephson frequency $f_J = 5.95 \times 10^{13}$ Hz. Infrared radiation with intensity spectrum having characteristics of coherent state of photons would be a signature of this current. The Josephson frequency corresponding to threshold potential is $f_J = 3.36 \times 10^{13}$ Hz.

f_J scales like $f_J \simeq \lambda^{-k_d}$ as a function of the level of the dark matter hierarchy. For $k_d = 4$ one obtains $f_J = 3.38$ Hz using $\lambda = 2^{11}$. This frequency belongs to delta band (defined as the the frequency range .25-5 Hz).

The original hypothesis about possible values of $\hbar$ must be taken with a grain of salt. There are reasons to argue that the most natural value for f_J is 5 Hz. $\hbar/\hbar_0 = 5 \times 2^{42}$ would give this frequency in good approximation.

6.3.4 Levels of dark matter hierarchy as a physical counterpart of chakras?

The model identifying generalized EEG as coherent photons emitted by Josephson junction suggest that $k_d = 7$ corresponds to the highest level of dark matter hierarchy for humans. This brings in mind the seven chakras central for Eastern mystic traditions. The magnetic flux quanta would enter the body through organs which are assignable to a particular value of k_d and chakras could be identified as groups of organs with a given value of k_d. An alternative possibility is that the space-time sheets at level k_d are joined to the level $k_d + 1$ by

Josephson junctions. In this case it is not necessary to have connections directly from the level of DNA.

The magnetic bodies involved include the magnetic body associated with biological body, presumably that associated with $k_{em} = 2$, magnetic body of Earth for $k_{em} = 4$, magnetic body associated with plasma sheet at night side of Earth's magnetosphere, the magnetic body of Sun for $k_{em} = 6$ and that of solar system for $k_{em} = 7$. Note however that the endogenous magnetic field is $B_{end} = .2$ Gauss and relates to $B_E = .5$ Gauss by a scaling factor. This suggests that personal magnetic bodies in the hierarchy interact with the astrophysical magnetic bodies but are not identical with them.

Josephson period associated with the largest chakra would would correlate with the time scales of intentional action and memories and would give a criterion making possible to estimate which levels are present for a given kind of organism or part of organism.

Of course, detailed one-to-one map between chakra picture and dark matter hierarchy is not possible. There are however common elements, most importantly the hierarchical structure of conscious experience leading from animal consciousness (root chakra) to cosmic consciousness (crown chakra). Chakra hierarchy should also have direct counterpart at the level of evolution of living organisms.

Hence it could be that two ideas, chakras and the idea about delicate interaction between astrophysical objects and human consciousness, hated bitterly by skeptics, find a natural place in dark matter hierarchy.

6.3.5 What is the precise value of λ?

The precise value of λ is important if one wants to assign the amplitude windows to resonance bands of EEG.

1. By the general model for quantization of Planck constant already discussed λ can correspond to a power of 2 and hence $\lambda = 2^{11}$ is strongly favored.

2. $\lambda = 2^{11}$ implies a precise resonance between dark length scales and ordinary p-adic length scales. If λ is integer and if it equals to 2^{11} then also lower powers of 2 can in principle appear in the dark matter hierarchy as sub-harmonics $\lambda/2^k$ (this is indeed predicted by integer quantization of Planck constant).

3. The interpretation of the Josephson period associated with the highest level of dark matter as the time scale for intentional action and memory allows to estimate the value of largest k relevant for humans and it turns out that the scaled up Josephson frequency corresponds to a period of 80 years for this option meaning that $k_d = 7$ naturally corresponds to the highest level in the dark matter hierarchy associated with humans.

4. $\lambda = 2^{11}$ option predicts for the length scale associated with $k_d = 4$ magnetic body a value having direct physical interpretation.

5. $\lambda = 2^{11}$ option provides a plausible interpretation for amplitude windows in terms of EEG resonance bands.

6.3.6 Josephson frequencies for various levels of dark matter hierarchy

The following tables list the Josephson frequencies for doubly charged current carriers for the levels of dark matter hierarchy corresponding to $k_d = 0, ..., 7$ using the value .08 V/m for the resting potential for $\lambda = 2^{11}$.

The powers of $\lambda = 2^{11}$ are allowed by the requirement that the scaling $\hbar = n\hbar_0$ of Planck constant corresponds to a quantum phase $q = exp(i\pi/n)$ assignable to an n-polygon constructible using only ruler and compass. In this case one has $n = n_F = 2^k \times \prod_k F_{n_k}$, where each Fermat prime $F_n = 2^{2^n} + 1$, $n = 0, 1..., 4$ can appear only once. The quantum phase $exp(i\pi/n_F)$ is expressible using using only iterated square root operation [C6] and same applies to the algebraic extension of p-adic numbers is needed for $p \; mod \; 4 = 3$. This is not true for $\lambda = 2176$ so that $v_0 = 2^{-11}$ remains the only candidate.

For $\lambda = 2^{11}$ the Josephson period for $k_d = 7$ is $\simeq 80$ years, which roughly corresponds to the duration of human life cycle. $k_d = 6$ corresponds to $\simeq 14.3$ days and $k_d = 5$ to $\simeq 10.1$ minutes.

Note that there is no dependence on the p-adic length scale $k = 151, ..., 169$. Also the frequencies corresponding to the .05 V corresponding to the potential at which nerve pulse is generated are listed. For singly charged bosonic ions the frequency would be $f_J/2$. For fermionic ions Josephson currents are not of course possible.

k_d	0	1	2	3
$f_J(80\ mV)/Hz$	5.95e+13	2.91e+10	1.42e+07	6.93e+03
$f_J(50\ mV)/Hz$	3.72e+13	1.82e+10	8.87e+06	4.33e+03
k_d	4	5	6	7
$f_J(80\ mV)/Hz$	3.38	6.18e-4	2.85e-7	1.31e-10
$f_J(50\ mV)/Hz$	2.11	1.0e-3	5.04e-07	2.46e-10

Table 45. The Josephson frequencies $f_J = 2eV/2\pi\hbar$ of doubly charged particles for $\lambda = 2^{11}$ corresponding to the resting potential .08 V and threshold potential .05 V for nerve pulse generation for $\lambda = 2^{11}$.

6.4 A more precise identification of layers of magnetic body

By fractally scaling up from the case of cell membrane one can assign to a given level of dark matter hierarchy the p-adic length scales $L(k)$, $k = 151, ..., 169$ scaled by the power 2^{11k} as a sequence of onion like layers of the magnetic body at given level of dark matter hierarchy in the newer model. In the older model the onion layers of magnetic body scaled by 2^{11k} would correspond to Josephson

junctions having key properties of the scale up cell membrane. The discussion below relies on the newer model.

6.4.1 $k_d = 0$ level

In the new model Josephson junctions involved with EEG are assigned with cell membrane. Note that electronic and exotic neutrino super-conductivities correspond to the ordinary value of $\hbar$. The Josephson frequency is 29.8 THz and corresponds to infrared photons. The observation of photons with spectrum having characteristics of coherent photon state generated by Josephson current is a testable experimental prediction.

An interesting question is whether membrane proteins acting as receptors and possibly also as channels and pumps correspond to a concrete realization of Josephson junctions and could be seen as being analogous to living organisms populating the cell membrane. Josephson junction would correspond to the protein magnetic body connecting cell interior to the magnetic body of cell. Second question is where the magnetic flux tube of the personal magnetic body flows in the cell interior and exterior. As a matter fact, the radius 18 μm of flux quanta for $B_{end} = .2$ Gauss resolves this question and suggests that large neurons of vertebrate brain are essential concerning the effects of ELF fields on brain.

If topological magnetic monopole flux flowing to a larger space-time sheet through wormhole contacts and returning back at the other end of the junction in the similar manner is in question, this question is avoided. The Josephson junctions identifiable as protein magnetic bodies can be associated with also other membrane bounded structures, in particular organelles inside cell, say cell nucleus.

With inspiration coming from the experiments of Gariaev [96] I have proposed that EEG has fractally scaled-up counterparts such that ordinary EEG would correspond to $k = 169$ level and scaled up variants to primes $k = 151, 157, 163, 167$ (at least). The model worked assuming that magnetic field scales like $B \propto 1/L(k)$: this is consistent with highly convoluted flux sheets. This scaling is just the reversal for the scaling of Josephson frequencies of external voltage perturbations as $f_J \propto L(k)$. These magnetic flux quanta can be associated with the coiling hierarchy of DNA.

6.4.2 $k_d = 1$ level

In this case one has $L(151) \to L(151 + 22 = 173) = 40$ μm. The upper bound for the size of layers of magnetic body would be $\lambda \times L(173) \simeq 4$ cm. Epithelial sheets consisting of double cell layer and surrounding organs correspond to size scale $L(173)$.

Josephson frequency is 29 GHz and corresponds to the time scale for the conformational dynamics of proteins. Josephson junctions could define a pacemaker for this dynamics and perturbations of the resting potential would serve a control purpose.

6.4.3 $k_d = 2$ level

The scale assignable to the corresponding layer of magnetic body is $\lambda = 2^{11}$ $L(195) = 4$ cm. The upper bound for these structures is 80 m and $L(169)$ corresponds now to 20 m length scale. This would require that magnetic flux sheets traverse through cell nuclei of a large number of organisms and thus define hyper-genes responsible for the social aspects of the behavior. At least the interiors of these structures must correspond to dark matter. The proposal that the magnetic flux sheets of $k_d = 4$ magnetic body flow through DNA of neurons generalizes to the proposal that flux sheets of $k_d = 2$ magnetic body flow through the DNA of cells which are at a lower level in the differentiation hierarchy. Josephson frequency would be 14 MHz.

6.4.4 $k_d = 3$ level

In this case the layer of magnetic body would have thickness $L(217) = 80$ m. The Josephson frequency would be 6.9 kHz. The length of DNA needed to guarantee minimal flux quantum width would be $\lambda^3 L(169) \simeq 40$ km so that roughly 4×10^4 cell nuclei are needed if most of the width of flux sheet corresponds to DNA. Thus supergenes would necessarily emerge at this level and involve organisms in a region of size scale 176 km. $k_d = 3$ layer of magnetic body defined by the magnetic flux sheet going through cell nuclei have size scale characterizing litosphere and ionospheric cavity.

6.4.5 $k_d = 4$ level

As already proposed, $k_d = 4$ level could correspond to that level in the hierarchy of personal magnetic bodies which connects organism to the magnetic body of Earth.

The length scale $\lambda^4 L(151)$ equals to 176 km for $\lambda = 2^{11}$. The cavity between ionosphere and Earth surface is about 100 km thick whereas litosphere plate has thickness about 80 km [23]. The layer responsible for atmospheric phenomena is about 10 km thick. 180 km thickness is consistent with 176 km thickness predicted by $\lambda = 2^{11}$. Litosphere plate + atmosphere and ionosphere above atmosphere could thus form the counterpart of bilayered cell membrane. This hypothesis makes sense since its is dark matter which is involved with the Josephson junction in question. If this where the case living organisms would be analogous to the proteins defining receptors, ionic channels, and pumps at the cell membrane. For this option the convoluted magnetic flux tubes defining Josephson junctions could carry monopole flux which returns back at the larger space-time sheet. In this hyper-genes would involve organisms in the scale of entire Earth.

In this picture vertebrates would be like magnetic plants extending from the bottom of litosphere to the ionosphere. These Josephson junctions would presumably connect parts of the magnetic body of Earth to each other. Josephson frequency is 3.4 Hz and belongs to theta band in EEG. The frequency is somewhat higher than the 3 Hz frequency associated with absence seizures. 3-4 Hz

posterior rhythm is established in EEG of 3 months old child in awake state. 5 Hz rhythm is established at the age of 6 months. A possible interpretation is that perturbing oscillatory voltage is superposed on the 3.4 Hz drum beat.

6.4.6 $k_d > 4$ levels

$k_d = 5$ corresponds to the length scale $L(151 + 5 \times 22 = 261) = .32$ Mkm to be compared with the solar radius $R = .7$ Mkm and Earth radius 6.3×10^3 km. Earth's rotating inner magnetosphere extends at night side to about 100 Earth radii which is of same order of magnitude as $L(261)$. The rather remarkable finding that equatorial plasma sheet is self-organizing system [24] which seems to represent in electron distributions patterns resembling "flowers", "eyes", etc... might have deeper meaning if plasma sheet corresponds to $k_d = 5$ level of dark matter hierarchy. I have indeed suggested the interpretation of these patterns as magnetospheric sensory representations [M1, N1].

Because of its size Sun could correspond to $k_d = 5$ level naturally. A possible interpretation is that all planets are accompanied by dark matter hierarchy involving also this size scale but that only in case of Sun there is considerable density of visible matter associated with this dark matter. In the case of Earth only plasma sheet would be associated to this level.

$k_d = 6$ corresponds to the length scale .64 Gkm and is of the same order of magnitude as the size of the planetary system (the distance to Sun about $AU = .146$ Gkm). $k_d = 7$ corresponds to the length scale 1.28 Tkm and could correspond to the size of solar magnetosphere. This size scale is .14 light years. The distance of nearest star is about 4 light years.

One can argue that a flux tube of thickness $L = 5L(169)/\sqrt{2}$ cannot follow every twist and turn of the highly convoluted DNA double strand. Many-sheeted space-time might save the situation. On the other hand, if the thickness of flux sheet is $L/\lambda = 8.8$ nm, it has almost the thickness of cell membrane and could adopt the shape of the convoluted DNA strand. The transversal dimension of base pair is indeed about 1.2 nm meaning that the thickness of the double strand is about 2.5 nm. Note that $k = 167$ could correspond to flux sheets traversing only single strand.

In this case the width of the flux sheet would be about 136 light years so that $k_d = 7$ level would indeed conform with the assignment of cosmic consciousness with the crown chakra. In this case the flux sheet should flow through $\sim 10^{15}$ neurons or cells and bind them to single string defining kind of super genome. The total number of cells in human body is estimated to be around 10^{14} so that hyper genes involving large number of different organisms should appear at this level if most of the flux sheet cross section contains DNA. As already noticed the estimate for the size of the scaled up version of nucleus implies that hyper-genes should appear already at $k_d = 2$ level.

6.5 Relation with the structure of CNS

Page of a book is rather precise metaphor for the magnetic flux sheet going through a linear array of strings of nuclei. This raises several questions. Do the lines of the text of this book correspond to axons in neural circuits? Do the pages correspond to larger structures formed by the axons? This might hold true for sufficiently large values of k_d, say $k_d \geq 2$.

Books are made for reading and one can thus ask whether the book metaphor extends. Could the observed moving brain waves scanning cortex relate to the "reading" of the information associated with these sheets of book by the magnetic body and does our internal speech correspond to this "reading"? One is also forced to ask whether these brain waves are induced by waves propagating along magnetic flux quanta of the magnetic body of Earth or personal magnetic body in the case that it has components other than magnetic flux sheets serving as Josephson junctions.

7 The effects of ELF fields on brain and high T_c ionic super conductivity

The article 'Spin the tale on the dragon' by David Jarron [77] gives excellent popular review about the history of the bio-electromagnetic research and about the frequencies for which electromagnetic fields have special effects on living matter and brain. The material from this article led to the realization of how brain manages to be a macroscopic quantum system in TGD Universe. A more technical view about the effects can be found from review articles of Adey and Blackman [78, 85]. The online review article of Cherry [90] provides a good technical representation about various effects of weak ELF em fields and ELF modulated radiofrequency em fields on brain and an extensive list of references.

7.1 Summary about effects of ELF em fields on brain

The work by pioneers of bio-electromagnetism (Wertheimer, Milham, Marino, Becker, Adey, Blackman and many others) which began already at sixties led to amazing discoveries about ELF fields on brain. The article of Blackman [85] provides a detailed summary of these developments. The results of the work of Bawin, Adey, Blackman and others can be summarized by saying that radio frequency em fields amplitude modulated by ELF frequencies affect in certain frequency and amplitude windows brain tissue [80, 82, 84]. The function of the radio frequency carrier wave is to facilitate the penetration of em field into tissue and its frequency is not essential for the occurrence of the effect. Presumably nonlinear effects give rise to a secondary wave with modulation frequency which is the primary source of effects.

7.1.1 Basic effects

The effects of ELF em fields on brain include chemical, physiological and behavioral changes within windows in frequency and field intensity. It is essential that the effects have been observed only in vertebrates which thus possess EEG. A good summary is the online review article of Cherry [90].

The well documented and established non-thermal biological effects of EMR include significant alteration of cellular calcium ion homeostasis, reduction of melatonin, and the detection of Schumann Resonances by human and avian brains. A key effect is change in Ca^{2+} homeostasis: Ca^{2+} it is involved with both pre- and postsynaptic steps of nerve pulse transmission and also with intracellular communication. For instance, Ca^{2+} is involved with gene expression, the development and plasticity of nervous system, modulation of synaptic strengths, and with $Ca^{2+} - c$AMP signal transduction process.

Change in Ca^{2+} homeostasis has harmful effects in central nervous system, endocrine system and immune system. At the level of CNS this means changes of reaction time and behavioral alternations. At the level of neuro-endocrine system a good example is the reduction of the melatonin production in pineal gland having wide variety of harmful effects since melatonin serves as effective scavenger of free radicals: among the effects are DNA strand breakage, chromosome aberrations and problems with gap junction communications. Melatonin is also crucial for healthy sleep and for the reduction of cholesterol and blood pressure. In case of immune system an example is provided by the change of functioning of lymphosytes in turn reducing the competence of immune system making the subject more vulnerable to allergens, toxins and viruses.

7.1.2 Amplitude windows

Two main amplitude windows have been seen. For the first window ELF em fields have values of electric field in tissue around 10^{-7} V/m. The effects are high level effects and associated with navigation and prey detection in marine vertebrates and with the control of human biological rhythms. For ELF modulated radio frequency fields (RF) and microwaves (MW) the intensities are around $1 - 10$ V/m. In this case the effects are neurophysiological effects are lower level effects at the level of the brain tissue. In case of brain tissue maximal sensitivity to electromagnetic fields occurs between 6 and 20 Hz.

In order to get grasp about orders of magnitude, it is good to notice that cell membrane electric field has a strength about 10^7 V/m whereas EEG electric fields in the range $5 - 10$ V/m. The fact that the second intensity window corresponds to $1 - 10$ V/m suggests that the em field simulates the em field associated with EEG: a valuable guideline in attempts to understand what is involved. For Schumann resonances electric field is of order .6 mV/m. For sferics (em perturbations associated with lightnings) magnetic field strength is not above nTesla: this corresponds to electric field strength 10 V/m associated also with EEG waves [21]. Field strength of V/m corresponds roughly to energy flux $\mu W/m^2$.

The presence of windows and weak intensities implies that the effects cannot be thermal. A good metaphor is the effect of radio noise on radio receiver: it occurs at definite frequency and destroys the information content of the original transmission.

7.1.3 The effects occur at harmonics of cyclotron resonance frequencies

Blackman also discovered that odd multiples 15, 45, 75, 105... of 15 Hz had much stronger effect on tissue than even multiples 30, 60, 90... Hz and realized a possible role of Earth's magnetic field [83]: it must be however emphasized that the value of magnetic field in question is $B_{end} = .2$ Gauss and smaller than $B_E = .5$ Gauss. A possible interpretation is that harmonics of cyclotron frequencies might be the information carrying frequencies in EEG.

In response to the results and speculations of Blackman, Liboff formulated ionic cyclotron resonance (ICR) model [89] based on the realization that the frequencies in question correspond to multiples of the cyclotron frequencies of Ca^{2+} ion in a magnetic field $B_{end} = .2$ Gauss. This model was classical. Later Blanchard and Blackman proposed so called ionic parametric resonance model (IPR) [87]. This phenomenological model combines ICR model with ideas about atomic physics. There are several objections against ICR model; classical orbits of ions in Earth's magnetic field have radius of order meters; dissipative effects and Brownian forces do not allow cyclotron orbits; charge-to mass ratios appearing in cyclotron frequencies correspond to vacuum rather than water environment characterized by a large value of dielectric constant; it is difficult to understand why odd multiples of cyclotron frequencies give rise to stronger effects [85]. Some of these objections apply also to IPR model.

The pattern of data seems to suggest that the interaction occurs at quantum level. This is in dramatic conflict with the predictions of the standard quantum theory and with the standard view about space-time.

7.1.4 Are quantal effects in question?

The conclusion that the effect of ELF fields on brain represents quantum effects associated with the transitions of ions confined in magnetic field having same strength as Earth's magnetic field, is supported by the following observations.

1. The frequencies $15, 30, 45, 60, 75$ Hz having effect on primates are multiples of the same basic frequency $f = 15$ Hz, which turns out to be the cyclotron frequency of Ca^{2+} ion in magnetic field $B_{end} = .2$ Gauss. That these frequencies come in multiples is a direct signature of quantum: in classical world only basic frequency $f = 15$ Hz should have effects (forcing ions to rotational motion around field lines with this frequency.

2. Even multiples of 15 Hz have a weak but non-vanishing effect. Transitions are not possible at all in the lowest order of perturbation theory since the

interaction Hamiltonian describing the transitions in question has non-vanishing matrix elements only between states of opposite parities in the dipole approximation applying when the wavelength of the radiation is much larger than the size of the radiating system [25]. Odd and even values of n for cyclotron states have opposite parities so that Δn odd rule results. In higher orders of perturbation theory also transitions for which transition frequency is even multiple of the cyclotron frequency are possible. This observation provides additional strong support for the hypothesis that quantum transitions are involved.

There are however also objections.

1. The cyclotron energy scale is about 10^{-14} eV and ridiculously small as compared to the energy scale .086 eV defined by room temperature so that quantal effects should be masked completely by thermal noise.

2. Also ELF em fields at spin flip frequencies (Larmor frequencies) should induce transitions. To my best knowledge these have not been reported.

3. The wave functions of ions in magnetic field are confined in a region of size of order

$$r_n \sim \sqrt{2n/eB} \ ,$$

which is of the order of cell size: macroscopic quantum state is in question. In fact, the value $.5 \times 10^{-4}$ Tesla for Earth's magnetic fields corresponds to the p-adic length scale $L(169) = 5$ μm rather precisely for minimal value of the magnetic flux quantized as $ZeBS = n2\pi$ obtained for $n = 1$ (S denotes the area of the flux tube) and $Z = 2$. If one requires quantum classical correspondence, very large values of n are required and cyclotron radii would be much larger than flux tube radius.

A common resolution of all these objections is provided by large $\hbar$ phases and hierarchy of magnetic flux sheets with B scaling like $1/hbar$ meaning that cyclotron frequencies scale down similarly and cyclotron energies remain invariant. Same applies to spin flip energies scaling in the same manner as cyclotron energies (for some time I thought that the scaling behaviors are different). By the quantization of the magnetic flux, predicted by TGD also classically, the minimal radius of the magnetic flux tube for the magnetic field of Earth of cell size for ordinary value of $\hbar$ but scales like $\hbar$ if magnetic field remains invariant and flux quantization $BS = n2\pi\hbar$ implying $S \propto \hbar$ holds true. This implies consistency with classical theory for large values of $\hbar = \lambda^{k_d}\hbar_0$, $\lambda \simeq 2^{11}$.

7.1.5 A brief summary of the model

Some work is required to end up with the following interpretation based on a model for how the different levels of dark matter hierarchy communicate and control.

1. Ions with charge Z, mass m and spin S in the external magnetic field behave quantum mechanically like harmonic oscillator with energies quantized as

$$E = E_c + E_L \quad , \quad E_c = (n + \tfrac{1}{2})\hbar\omega_c \quad , \quad E_L = S_z \tfrac{g\omega_c}{2} \quad , \quad \omega_c = \tfrac{ZeB}{m} \quad (c = 1) \quad . \tag{29}$$

   The first contribution corresponds to cyclotron contribution. For a given value of n the component of angular momentum in the direction of B has $n + 1$ values $n, n - 2, ..., -n$. E_L denotes spin (Larmor) contribution. g is so called Lande factor which for free elementary fermions equals to $g = 2$. Since S_z is invariant under the scalings of $\hbar$, Larmor contribution is negligible as compared to cyclotron contribution for large values of $\hbar$. The contribution to energy coming from the free motion in the direction of magnetic field has not been written.

2. The model for high T_c superconductivity involving competition of two superconductivities, one associated with cell interior and second with cell membrane is the starting point. These phases coexist in a narrow range around critical temperature and 36-37 C range where the effects are observed is a good candidate for this range.

3. Experimental findings suggests strongly that external em field induces resonant transitions between cyclotron states: these transitions are identified as transitions inside the cell/nucleus or its fractally scaled up variant. For $k_d = 4$ level of dark matter hierarchy cyclotron energy scale turns out to be above the thermal energy $2.88T$ of photons at maximum intensity of black body radiation at room temperature for $A \leq 223Z$. Cyclotron radiation can drive charged particles to smaller space-time sheets and this is essential for the metabolism and this process is expected to be part of the interaction of ELF em fields with cell nucleus. The scale of cyclotron energies for $k_d = 4$ level of dark matter hierarchy is indeed turns out to be consistent with this assumption.

4. The ELF em field used in the experiments have electric fields strengths in two windows: one around 10^{-7} V/m and second corresponding to $1 - 10$ V/m. Even in the latter case the field is by a factor of order million weaker than membrane potential: the notion of many-sheeted space-time allows to understand why so weak fields can have effects on biomatter. Amplitude windows are a further mystery related with the interaction of ELF em fields with brain tissue: if ELF em field defines potential difference eV associated with a Josephson junction, one might understand this effect in terms of quantum jumps induced by Josephson current with frequency $f = ZeV/2\pi$.

5. Dark matter hierarchy leads to the hypothesis that there is entire hierarchy of EEGs generated as coherent photon states by Josephson currents associated with the Josephson junctions whose thickness scales as $\hbar$ and frequency scales as $1/\hbar$ so that cyclotron energy remains invariant and is above the thermal threshold. For each value of $\hbar$ there is also p-adic hierarchy corresponding to $k = 151, ..., 169$ with same Josephson frequency: these levels combine to form single block for dark matter hierarchy formed from the scaled up variants of this block. At least the magnetic flux tube structure of DNA and membrane structure appear as scaled up copies. The lowest level corresponds to cellular or nuclear membrane and ordinary value of $\hbar$.

6. Josephson current is of form $J \propto sin(2eVt + 2e \int V_1 dt)$ and its amplitude does not depend on the strength of the perturbation V_1. V_1 is same for all values of $\hbar$ but scales like $L(k)$ as function of p-adic length scale for given value of $\hbar$. Perturbation is represent as EEG pattern communicated to the magnetic body of fractally scaled up variant of cell or cell nucleus, which reacts appropriately. At the limit when the Josephson frequency $f_J^1 = 2eV_1/2\pi\hbar$ of perturbation satisfies $f_J^1 \gg f_c$, the amplitude of perturbation is coded to frequencies $f_\pm = f_J^1 \pm f_J$ in the EEG in a good approximation.

7. The response of the system is that of AND gate. V_1 induces in the neuronal nucleus or its scaled up counterpart cyclotron transitions if the frequency is correct. If this the case, cell nucleus opens up communication line receiving possible control signals from the magnetic body at higher level of hierarchy. V_1 induces in Josephson junctions effects if the amplitude is in the amplitude window guaranteing that the frequencies $f_\pm$ belong to EEG resonance bands (or their scaled up variants. In this case magnetic body receives representation of V_1 as coherent photons and responds. If communication line is open the response induces in the cell nucleus gene translation and other activities necessary for the biological response. The model implies that cyclotron frequencies code for the biologically relevant information carried out by classical electric fields so that noise is eliminated very effectively.

7.2 Interpretation of the temperature window

The effects of ELF em fields on matter have been observed only in a temperature window 36-37 C around body temperature. The model of high T_c super-conductivity as a quantum critical phenomenon predicts that there is a narrow interval around T_c around which two competing phases corresponding to ordinary value and scaled up value of $\hbar$ compete. More generally, dark matter hierarchy should correspond to a hierarchy of quantum criticalities. A fractal hierarchy of cusp catastrophes such that the next cusp is inside the critical line of the previous cusp would be a convenient manner to visualize the situation. Each big leap in the evolution corresponds to the emergence of a new level k_d

in the dark matter hierarchy made possible by the external conditions allowing co-presence and competition of phases corresponding to $k_d - 1$ and k_d.

Quantum critical high T_c super-conductivity for electrons and protons (at least) is the essential prerequisite for the existence of Josephson currents through the cell membrane and its scaled up variants, and thus the hierarchy of generalized EEGs. Electronic super-conductivity is expected to be possible in a very limited temperature range usually idealized with single critical temperature. Quantum critical phase is analogous spin glass phase possible in a finite interval around critical temperature, and one can indeed speak of quantum spin glass phase for which the analogs of regions with fixed direction of magnetization are 4-dimensional rather than 3-dimensional and static. This relates to the breaking of the strict classical determinism of the basic variational principle of TGD having interpretation in terms of space-time correlate for quantum non-determinism in long time and length scales. Quantum coherence and quantum nondeterminism in long scales is obviously what makes system living. An educated guess is that the critical range of temperatures allowing quantum criticality and high T_c super-conductivity is just 36-37 C: this in turn implies that the effects of ELF em fields occur only in this temperature range.

7.3 Interpretation of amplitude windows in terms of resonance bands of generalized EEGs

7.3.1 Basic observations

The first amplitude window corresponds to $E \in [1, 10]$ V/m. Second window is around $E = 10^{-7}$ V/m. The following observations are crucial in attempt to understand what these windows correspond to.

1. The ratio of average electric fields for amplitude windows is $\sim 5 \times 10^7$. This is not too far from $\lambda^2 \simeq 4 \times 10^6$. This would suggest that the two windows correspond to levels k and $k + 2$ of dark matter hierarchy.

2. In Josephson junctions electric field is converted to voltage which in turn defines Josephson frequency. The voltage over junction is represented as a Josephson current generating coherent state of photons. The electric field is thus represented as biological actions induced by the absorption of coherent (dark photons) photons. Also the decoherence of these photons to ordinary photons would be involved.

These observations allow to construct a model for amplitude based on the idea that they correspond to resonance bands for generalized EEGs associated with p-adic and dark matter hierarchies.

7.3.2 Could amplitude windows correspond to the resonant EEG bands for the generalized EEGs?

In the proposed model of EEG the amplitude of oscillatory perturbation $V_1 sin(2\pi ft)$ of the voltage of Josephson junction is coded to Josephson frequency $f_J^1 =$

$2eV_1/2\pi\hbar$ and for $f_J^1 \gg f$, the frequencies $f_\pm = f_J \pm f_J^1$ appear in the generalized EEG spectrum as fundamental frequencies so that amplitude is coded to frequency. The frequency f itself defines the duration of the periodically occurring modulation of Josephson current. This would suggest that the amplitude windows correspond to frequencies $f_J \pm f_J^1$ belonging to the resonant bands in the generalized EEG.

The requirement $f_J^1 > f_c$, the condition that f_J^1 and f_J are of same order of magnitude, and the condition that the scaled down counterpart of $f_\pm = f_J \pm f_J^1$ in ordinary EEG belongs to the range of EEG frequencies, fix uniquely the selection of k and k_d for both $E \in [1-10]$ V/m and $E = 10^{-7}$ V/m.

7.3.3 Josephson frequencies associated with amplitude windows

In the table below the Josephson frequencies associated with the perturbations $E = 1$ V/m, $E = 10$ V/m and $E = 10^{-7}$ V/m as a function of p-adic length scale. There is no dependence on the level of dark matter hierarchy.

k	151	157	163	167	169
$f_J^1/MHz(1\ V/m)$	3.72	29.8	238	952	1905
$f_J^1/MHz(10\ V/m)$	37.2	298	2380	9520	19050
$f_J^1/Hz(10^{-7}\ V/m)$	0.37	2.98	23.8	95.2	190.5

Table 6. Josephson frequencies f_J^1 having relevance for periodic perturbations satisfying $f_J^1/f \gg 1$ as a function of p-adic length scale. The frequencies are given for $E = 1V/m$, $E = 10$ V/m and $E = 10^{-7}$ V/m.

It is quite possible that also other values of k in the range $151, ..., 172$ are possible and this is indeed suggested with the experience with p-adic mass calculations which favor also other values of k besides integers.

7.3.4 Amplitude window $1-10$ V/m

In this case $f_J^1 \gg f_c$ condition is trivially satisfied. $k_d = 2$ is the only possible choice for dark matter level and corresponds to 2+2 cm Josephson junctions. $k = 151$ and $k = 157$ are the only possible candidates for the p-adic length scale in question. For $k = 157$ the upper limit for f_J^1 however corresponds to a frequency above the range 1-100 Hz of EEG frequencies so that this option looks implausible.

In order to utilize the intuition about ordinary EEG, one can translate scaled down the frequencies by a factor λ^{-2}. For $k = 151$ the scaled down frequencies satisfy

1. $f_+ \in [4.48, 12.85]$ Hz and $f_- \in [2.62, 5.75]$ Hz for $\lambda = 2^{11}$,
2. $f_+ \in [4.08, 12.45]$ Hz and $f_- \in [2.22, 6.15]$ Hz for $\lambda = 2.17 \times 10^3$.

   f_+ and f_- cover delta, theta, and alpha bands and part of beta band. If the proposed interpretation is correct, the detailed dependence of the

effect on V_1 should reflect the resonance band structure of EEG in this region.

7.3.5 Amplitude window around $E = 10^{-7}$ V/m

The condition $f_J^1 > f_c$ allows $f_\pm$ type EEG resonance only for $k = 163$ and $k_d = 4$ level of dark matter hierarchy.

1. For $\lambda = 2^{11}$ one has $f_+ = 27.1$ Hz and $f_- = f_J^1 - f_J = 20.4$ Hz. 27 Hz frequency corresponds to a resonance frequency in the EEG of dog induced by stimulation with monochromatic light [74]. $f_- = 20.4$ is very near to the second harmonic of the fundamental 10 Hz alpha peak and Schumann frequency 20 Hz.

2. $\lambda = 2.17 \times 10^3$ gives $f_+ = 26.4$ Hz and $f_- = 21.1$ Hz. f_+ is between Schumann resonance 26 Hz and 27 Hz resonance.

   $\lambda = 2^{11}$ is favored by the following observation. $f \sim 3$ Hz peak in EEG correlates with spike activity accompanying absence of seizures. For $k = 151$ one has $f_- = f_J(151) - f_J^1 = 3.38 - .37$ Hz $= 3.01$ Hz for $\lambda = 2^{11}$. Slowly varying perturbations with frequency $f < f_J^1(157)$, perhaps some cyclotron frequency, could induce resonant oscillation with frequency $\simeq 3$ Hz, which corresponds to A=100 (^{99}Ru).

7.4 Why it is necessary to have both cyclotron frequency and amplitude in the window?

The explanation of amplitude windows leaves for cyclotron frequencies a very passive role and there seems to be no special reason for why the frequency of V_1 should correspond to cyclotron frequency. What seems to be the simplest interpretation for the situation is that there is a kind of AND gate involved. A non-vanishing net effect requires too separate effects which can be assigned with the membrane and interior of the structure involved, most naturally cell nucleus or its scaled up counterpart. This makes sense if one assumes that the magnetic flux sheets have DNA strands or as fractality suggests, their scaled up variants as transversal sections.

This conforms with the general vision that high T_c superconductivity involves two different competing super conductivities at quantum criticality, which presumably corresponds to the temperature interval 36-37 C in the recent case. Quantum criticality is a necessary prerequisite that AND gate gives result 1. The supra currents flowing in the interior of cell or its nucleus correspond to large $\hbar$ variant of BCS superconductivity. Second superconductivity corresponds to surface supra currents flowing along the membrane of cell or nucleus. For the surface super-conductivity the notion of Josephson junction makes sense only in synaptic contacts or gap junctions since the electrons of Cooper pair belong to different lipid layers. Josephson junctions between interior and exterior are a sensible concept if both are in large $\hbar$ phase. For cell nucleus inside

cell this holds true. This kind of Josephson junctions could be also between two cells in synaptic contacts or gap junctions. This consideration generalizes straightforwardly to the scaled up version of cell and cell nucleus.

Consider now how the hierarchy of AND gates could be realized.

1. At cell membrane the perturbation V_1 affects Josephson junctions. For this effect the value of the frequency is not essential as long as the condition $\omega_J^1 \gg \omega$ is satisfied. V_1 affects generalized EEG. This means essentially a representation of V_1 in terms of EEG frequency and communication of this information to higher level magnetic body, which then reacts to situation by sending a control signal. The effects are therefore high level "behavioral" rather than direct "physiological" effects (this is of course relative concept due to the hierarchy). Indeed, in case of $E = 10^{-7}$ V/m perturbations the effects are high level effects affecting prey detection and navigation. Note that the size of the effect do not depend on the amplitude as long as $\omega_J^1 \gg \omega_c$ is satisfied since it is the phase of Josephson current rather than amplitude that is affected by V_1. This is absolutely essential for the universality of EEG amplitudes. If EEG wave indeed results it has amplitude in the range 5-10 V/m it it is expected to induce similar effect at $k_d = 2$ level of hierarchy if the proposed interpretation for $E \in [1 - 10]$ effects is correct. This means that also communication to lower levels occurs automatically. Here the amplitude window condition is guaranteed by the properties of Josephson current.

2. V_1 induces also cyclotron transitions in the cell nucleus or its fractally scaled up counterpart and in this manner affects the competing BCS type interior supra currents and BE condensates. Any controlled biological activity must involve the activation of genome inducing the translation of genes to amino-acid sequences needed to realize the needed action. Hence the AND gate could be realized in a simple manner: cyclotron transitions would simply turn the communication line from magnetic body to nucleus on. If the frequency is wrong, the higher level magnetic body receives the message and responds but since the nucleus does not experience the cyclotron transitions it is off-line and nothing happens. If amplitude is not in the window but frequency is correct, the communication lines is on but no signal goes to the magnetic body and no command for action is received.

8 What is EEG made of?

The usual classification of EEG frequencies by EEG bands is more or less a convention and the definitions of various bands vary in frustratingly wide ranges. In a more ambitious approach bands should be replaced with some substructures identified on basis of their physical origin and function. In the proposed framework this is possible. This identification of substructures of course applies only

to that part of EEG from which noise is subtracted. The contribution of neural activity is one such source of noise, often regarded as the only contribution.

8.1 The most recent model for the generation of nerve pulse

Quite recently I learned [106, 107, 108, 109, 110] (thanks to Ulla Mattfolk) that nerve pulse propagation seems to be an adiabatic process and thus does not dissipate: the authors propose that 2-D acoustic soliton is in question. Adiabaticity is what one expects if the ionic currents are dark currents (large $\hbar$ and low dissipation) or even supra currents. Furthermore, Josephson currents are oscillatory so that no pumping is needed. Combining this input with the model of DNA as topological quantum computer (tqc) [O4] leads to a rather precise model for the generation of nerve pulse.

1. The system would consist of two superconductors- microtubule space-time sheet and the space-time sheet in cell exterior- connected by Josephson junctions represented by magnetic flux tubes defining also braiding in the model of tqc. The phase difference between two super-conductors would obey Sine-Gordon equation allowing both standing and propagating solitonic solutions. A sequence of rotating gravitational penduli coupled to each other would be the mechanical analog for the system. Soliton sequences having as a mechanical analog penduli rotating with constant velocity but with a constant phase difference between them would generate moving kHz synchronous oscillation. Periodic boundary conditions at the ends of the axon rather than chemistry determine the propagation velocities of kHz waves and kHz synchrony is an automatic consequence since the times taken by the pulses to travel along the axon are multiples of same time unit. Also moving oscillations in EEG range can be considered and would require larger value of Planck constant in accordance with vision about evolution as gradual increase of Planck constant.

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

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

4. New physics would enter in several manners. Ions should form Bose-Einstein cyclotron condensates. The new nuclear physics predicted by TGD [F9] predicts that ordinary fermionic ions (such as K^+, Na^+, Cl^-) have bosonic chemical equivalents with slightly differing mass number. Anomalies of nuclear physics and cold fusion provide experimental support for the predicted new nuclear physics. Electronic supra current pulse from microtubules could induce the kick of pendulum inducing nerve pulse and induce a small heating and expansion of the axon. The return flux of ionic Josephson currents would induce convective cooling of the axonal membrane. A small transfer of small positive charge into the inner lipid layer could induce electronic supra current by attractive Coulomb interaction. The exchange of exotic W bosons which are scaled up variants of ordinary $W^{\pm}$ bosons is a natural manner to achieve this if new nuclear physics is indeed present.

8.2 Basic contributions to EEG and ZEG

There are three fundamental contributions to EEG (or hierarchy of EEGs) besides the neuronal noise. This picture applies more or less as such also to ZEG.

1. Schumann resonances whose interpretation should be clear. These frequencies do not depend on magnetic field strengths assignable with magnetic flux sheets and characterize Earth's magnetic field and collective aspects of consciousness.

2. Cyclotron frequencies generated in cyclotron transitions of ions. An attractive guess is that cyclotron frequencies correspond directly to the control signals from the magnetic body or that they result as a consequence of the generalization actions of the magnetic body so that Josephson junctions and magnetic body would form a closed feedback loop. For instance, ions could drop during generalized motor actions to excited cyclotron states at dark magnetic flux quanta and their decay would produce dark cyclotron photons. Cyclotron frequencies can be classified to those associated with bosonic and fermionic ions respectively. The transitions of Bose-Einstein condensates of bosonic ions are of special interest. The

scale of these frequencies could be be subject to homeostatic regulation which is local and can vary even inside genes of a given nucleus.

3. The frequencies generated by Josephson currents as coherent photons. Harmonics of cyclotron frequencies shifted upwards and downwards by Josephson frequency $f_J = 5$ Hz. If the amplitude of the perturbation at cyclotron frequency is strong the EEG looks locally like it would consists of amplitudes with frequencies $f_\pm = f_J^1 \pm f_J$ during most of the cyclotron period so that the visual inspection of time evolution of EEG can be rather misleading. Since these frequencies are involved with communications to the magnetic body of Earth, the natural guess would be that they correlate with the neural processing.

The following general overview about quantum communication and control emerges in this framework.

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

2. One of the basic functions of cell membranes is to perceive the chemical environment using various kinds of receptors as sensors. Neurons have specialized to receive symbolic representations of the sensory data of primary sensory organs about the situation in the external world. Receptor proteins would communicate cell level sensory input to the magnetic body via MEs parallel to magnetic flux tubes connecting them to the magnetic body. We ourselves would be in an abstract sense fractally scaled up counterparts of receptor proteins and associated with dark matter ionolito Josephson junction connecting the parts of magnetosphere below litosphere and above magnetosphere.

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

4. In the length scales below the weak length scale L_w also charged weak bosons behave as massless particles and the exchange of virtual W bosons makes possible a nonlocal charge transfer. Dark quark-antiquark pairs associated with the color bonds of the atomic nuclei can become charged via the emission of dark W boson and thus produce and exotic ion. The same can happen at the higher levels of dark matter hierarchy. This provides a nonlocal quantal mechanism inducing or changing electromagnetic polarization in turn inducing ordinary charge flows and thus making possible quantum control.

5. 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 (hierarchy of WEGs!) 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 dark charge inside neuron and thus by Faraday's law also 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.

To sum up, charged massless extremals could be seen as correlates for nonlocal quantum control by affecting charge equilibria whereas neutral MEs would serve as correlates for coordination and communication. Color charged MEs could also induce color charge polarization and flows of color charges and thus generate visual color qualia by the capacitor mechanism discussed in [K3].

8.3 Classification of cyclotron frequencies

Consider now the classification of cyclotron frequencies ($B_{end} = .2$ Gauss will be assumed).

1. Cyclotron frequencies can be classified those associated with atomic and molecular ions. For biologically important atomic ions most frequencies are above 7.5 Hz. For molecular ions frequencies are lower and for DNA sequences the frequencies are in delta band. Thermal stability condition suggest a lower bound of ~ 1 Hz for significant frequencies of this kind. Thus it would seem that delta band dominating during deep sleep corresponds to DNA and possibly other bio-molecules and EEG during wake-up state corresponds to atomic ions.

2. Atomic ions can be classified into bosonic and fermionic ions. Practically all biologically important bosonic ions have $Z = 2$ and in alpha band: $f(^6Li^+) = 50$ Hz and $f(Mg^{2+}) = 25$ Hz are the only frequencies above alpha band. Situation is essentially the same for biologically interesting ions too. $^7Li^+$ is exception and corresponds to 42.9 Hz: as a fermionic ion it does not possess satellites and does not contribute to Josephson part of EEG. Thus the frequency range $7.5 - 15$ Hz is very strongly represented and expected to be fundamental.

3. Also the position in the periodic table of elements provides a classificational criterion but this criterion does not seem to be so useful as thought originally.

4. The integer n characterizing the harmonic of the cyclotron frequency in question is an additional classificational criterion and n could correlate with the character of neural processing.

8.4 Wake-up EEG

The question is whether this classification is consistent with the conventional decomposition into various bands and whether it allows to gain some real insights EEG. Consider first wake-up EEG [57].

1. The first implication is that each cyclotron frequency f_c is accompanied by by two satellites $f_c \pm f_J$. For alpha band these satellites correspond to theta band and beta band identifiable as responses to control signals from magnetic body in alpha band. One can ask whether these bands as a whole correspond to the satellites of alpha band. This identification implies that both bands are present and makes sense for wake-up EEG but not as such for the EEG during first and second period of deep sleep during which theta band is present but higher bands are absent.

2. Sensorimotor rhythm in range (12-16) Hz is associated with physical stillness and body presence. The interpretation is as a low amplitude satellite of alpha rhythm with low amplitude control signals from the magnetic body so that rhythmicity is not lost and frequencies are clearly $f_c + f_J$.

3. Beta band is above 12 Hz and associated with active, busy or anxious thinking and active concentration and is chaotic and highly asynchronous. The natural interpretation is as large amplitude satellite of alpha band involving the activation of communications to the magnetic body and large control signals with $f_J^1 \gg f_c$. Hence the spectra would for a considerable part of period $1/f_c$ effectively consist of frequencies $f_\pm = f_J \pm f_J^1$, where f_J^1 varies in frequency range characterized by the amplitude of perturbation. There is no definite resonance frequency since ω_1^J can vary continuously. Globally the situation is different since the spectrum can in principle be decomposed to frequencies $f_J \pm nf_c$. These two descriptions correspond to time domain and genuine frequency domain.

   For sufficiently high harmonics of f_c the chaoticity disappears and frequencies $f_J \pm nf_c$ become more manifest. The Josephson amplitudes of higher harmonics decrease as $1/nf_c$.

   Beta band is predicted to have a mirror image in theta band during cognitive activity. The frequencies in theta band are assigned with cognitive activities and memory recall. Note that also alpha band due to cyclotron frequencies should be present as well as the basic "drum beat" defined by f_J for $f_J^1 \gg fc$.

4. Odd higher harmonics of cyclotron frequency are expected to be the most important ones and would have interpretation as control signals from magnetic body. Satellites would correspond to responses to magnetic body involving entire 160 km thick Josephson junction but certainly correlating strongly with what happens in brain (recall the analog of biological body with a receptor at cell membrane).

   For alpha band the third harmonics of most bosonic ions are in the range 28.2-34.2 Hz and roughly in gamma band above 30 Hz assignable with the control of cognitive activities from a flux quantum of Earth's magnetic field.

   Fifth harmonics would be be in the range 37.5-57 Hz. The fermionic ion Na^+ would correspond to 65 Hz. During REM sleep EEG very similar to awake but 65 Hz resonance is present. One can ask whether fifth harmonics are present during REM sleep and serve as correlates for conscious visual imagery.

5. 40 Hz thalamocortical resonance band is very important EEG band. The upper satellite of the third harmonic of Mn^{2+} is 37.9 Hz. The third harmonics of fermionic ions $^7Li^+$ and Na^+ correspond to 42.9 Hz and 39 Hz (Schumann resonance) and have no satellites as fermionic ions.

8.5 Satellites exist as mirror pairs!

The existence of the mirror satellites might be regarded as a killer prediction. Amazingly, narrow EEG bands which are mirror images of each other with respect to alpha band have been reported [74]. Besides alpha band at 11 Hz, Nunez mentions also narrow sub-bands at 3, 5 and 7 Hz at delta and theta range, as well as the bands at 13, 15 and 17 Hz in beta band [74]. All these frequencies are expressible in the form $f_c \pm f_J$, $f_J = 5$ Hz, which is one half of the frequency 10 Hz of the memetic code and by 14 per cent higher than 3.7 Hz predicted assuming $\lambda = 2^{11}$. The value of λ deduced from these frequencies would be $\lambda = 1902$ and about 7 per cent smaller than $\lambda = 2^{11}$. This estimate cannot be taken too seriously since it is quite possible that the thickness of Josephson junction is not scaled up completely exactly.

The cyclotron frequencies associated with the bands are 8, 10, and 12 Hz. The cyclotron frequencies of bosonic ions $^{80}Se^{2-}$, $^{64}Zn^{2+}$, and $^{55}Mn^{2+}$ for a magnetic field strength $B_{end} = .2$ Gauss are 8.00, 9.90, and 12.00 Hz. The cyclotron frequencies of bosonic ions $^{59}Co^{2+}$ and $^{56}Fe^{2+}$ would be 10.52 Hz and 11.36 Hz and the satellites are at frequencies 5.52 Hz and 6.36 Hz and 15.52 and 16.36 Hz. All these frequencies belong to the bands reported by Nunez since their widths are 1-2 Hz. Thus the frequencies of all bosonic ions in alpha band and in their satellites belong to the bands reported by Nunez for values of λ and B very near to their nominal values used in calculations!

With these assumptions the frequencies $3f_c(Mn^{2+}) \pm f_J$ are 40.97 Hz and 30.97 Hz corresponding to 40 Hz band and the threshold of gamma band. That $f_c(O^{2-}) = 39.6$ Hz is also in this band suggests additional reason for why oxygen

is so important for consciousness. $f_c(Mg^{2+}) = 26.3$ Hz is very near to Schumann resonance 26 Hz and its upper satellite corresponds to the threshold of gamma band.

What is also very remarkable that the 10 Hz magic frequency of the memetic code corresponding to the secondary p-adic length scale $L(2, 127)$ associated with Mersenne prime M_{127} characterizing electron appears. It should be also noticed that $f_J = 5$ Hz frequency corresponds to cognitive theta appearing during tasks requiring mathematical skills.

8.6 Alpha band dominance during relaxed state

In a relaxed state beta band disappears and the spectral power in alpha band increases. This seems to be in conflict with the idea that beta band is a mere satellite. There are two mutually non-inclusive manners to understand this.

1. The first possibility is that cyclotron frequencies in alpha band are not actually present and only Schumann frequency 7.8 Hz and 10 Hz resonance frequency associated with the excitations of electric field in ionospheric cavity behaving like 2-dimensional waves on sphere.

2. Second possibility is that ionospheric Josephson junction is somehow closed so that only the cyclotron contribution of various ions is present. This might be caused by DNA level mechanism which simply prevents the flow of the Josephson currents flowing along magnetic flux sheets through DNA strands. This mechanism would be completely analogous to the closing of ionic channel associated with cell membrane protein.

8.7 EEG during sleep

The EEG during sleep [58] provides a testing ground for the proposed anatomy of EEG. Sleep consists of 90 + 90 minute periods of NREM and REM sleep. This period is also the period of brain hemisphere dominances during wake up and day dreaming occurs with the same period as REM sleep. During REM sleep the EEG is essentially similar to that during wake-up. These observations inspire the hunch that brain hemisphere dominance dictates whether REM or NREM is in question. This turns out to be a correct guess.

8.7.1 EEG during stage 1

During stage 1 theta of deep sleep [58] waves in frequency range 4-8 Hz dominate and amplitudes increase when frequency is reduced. The control signals from magnetic body are expected to be weak so that $f_J^1 < f_J$ approximation should hold true implying that frequencies $f_J \pm f_c$ should dominate and EEG would look rhythmic rather than chaotic as indeed observed. The amplitudes behave as $1/\omega_c$ and thus increase with decreasing ω_c. The fact that amplitudes increase with decreasing EEG frequency suggests that the frequencies they correspond to different cyclotron frequencies.

These facts does not conform with the general picture as such. If theta and beta bands are mere satellites of alpha band, both of them should be present during stage 1 sleep but this is not the case. The idea that cyclotron frequencies of heavier ions in $B_{end} = .2$ Gauss could replace those appearing during wake-up does not work. Theta band simply does not contain the cyclotron frequencies of biologically important ions for $B_{end} = .2$ Gauss. One can imagine two manners to resolve the difficulty.

1. Two manners to quantize magnetic flux

One way out of difficulty seems to be that the value of the magnetic field associated with active flux sheets is reduced by a factor of 1/2. This would mean that the most important range 7.5-15 Hz of cyclotron frequencies would be scaled down to 3.75-7.5 Hz which indeed corresponds to the theta band. If one excludes Ca^{2+}, the range for bosonic ion reduces from $7.5-11.4$ to $3.75-5.7$ Hz. The satellites correspond to the range $.05 - 8.7$ Hz and $7.45 - 9.4$ Hz plus Ca^{2+} satellites at 3.8 Hz and 11.2 Hz. With Ca^{2+} forming a possible exception, the resulting frequency ranges are consistent with empirical facts. Of course, it is quite possible that magnetic body does not generate cyclotron transitions at Ca^{++} cyclotron frequency.

One can image several manners to resolve the problem but the most natural resolution of the puzzle came with the frustrating realization that $B_{end} = .2$ Gauss explaining the observations of Blackman and others is not equal to the Earth's magnetic field $B_E = .5$ Gauss. Although B_{end} corresponds to $k = 169$, the value of Planck constant is $\hbar = 5\hbar_0$ and flux unit is $h_5 = 5h_0$. For B_{end} $k = 169$ flux tubes carry two units of flux and for $B_{end}/2$ single unit so that the halved value of B_{end} emerges very naturally.

The different values of field intensities might relate to the character of ions at the flux sheets in left and right hemisphere.

1. The quantization of magnetic flux reads as $Ze \int BdS = n\hbar$ and for Cooper pairs and bosonic ions with $Z = 2$ (Z refers to the absolute value of charge) it gives magnetic field strength which is one half from that for fermionic singly charged ions. Both fermionic ions with $Z = 1$ and bosonic ions and Cooper pairs with $Z = 2$ are allowed in this case by the single valuedness of wave functions. For $Z = 2$ the quantization condition allows single valued wave functions for $Z = 2$ ions or Cooper pairs only.

2. Assume the quantization condition corresponds to $Z = 1$ for the left hemisphere and $Z = 2$ for the right hemisphere. The presence of fermionic ions implies additional cyclotron frequencies on left hemisphere and the presence of fermionic ions conforms with the old proposal that fermionic Fock states provide a realization of quantal version of Boolean algebra. This conforms with the view that left brain is more reductionistic and performs linear logic operations whereas right brain is more holistic.

3. As a consequence the cyclotron frequency scale in right hemisphere is reduced by a factor of 1/2 and during right hemisphere dominated NREM

sleep alpha band would be scaled down to theta band.

4. The prediction is that, apart from the Schumann frequencies and neural noise, left hemisphere EEG spectrum consists of right hemisphere EEG specrum scaled up by a factor of 2 plus the contribution of fermionic ions and the Josephson satellites of these frequencies.

The assumption that the two quantization conditions correspond to just left and right hemispheres rather some other pair is of course un-necessarily strong and one can imagine also other correspondences.

2. Exotic ions as a resolution of the problem?

Second manner to achieve the scaling down of alpha band by a factor of 1/2 relies on the notion of exotic atomic nuclei. Z^0 ions coupling to $k = 113$ exotic weak bosons with $k_d = 2$ result if some color flux tubes bonding the nucleons of nuclei to nuclear string become weakly charged. This means that a color bond having quark and antiquark at its ends becomes $u\overline{d}$ type bond or its charge conjugate so that color bond becomes also em charged. There is evidence for this process. For instance, TGD explains the properties of tetraneuron assuming that alpha particle with two negatively charged color bonds is in question [F8].

Exotic ion is not chemically equivalent with an ion of same em charge since the valence of the system is anomalous. For instance, as far as electronic shell is considered, the ion could behave like noble gas atom. Electronic ionization could also compensate exotic ionization so that an electromagnetically neutral but weakly charged ion would result. For instance, doubly charged bosonic ions could have em neutral counterparts with two units of weak charge (unit defined as the weak charge of $u\overline{d}$ type color bond).

Since fermion number is not affected, singly charged exotic ion is boson for all nuclei with even neutron number, that is for the most stable nuclei. All biologically relevant ions might thus exist in bosonic states and form Bose-Einstein condensates. One can even wonder whether ions such as Na^+, K^+, and Cl^- associated with cell are actually exotic ions and appear as Bose-Einstein condensates. For doubly charged bosonic ions, most of which are in alpha band, cyclotron frequencies of singly charged exotic counterparts would be halved. Also the Josephson frequency would be halved. For the first option this is not the case.

8.7.2 EEG during stage 2

Sleep spindles appearing in the state 2 of deep sleep are sudden increases in EEG amplitude and frequency from theta band to 12-16 Hz [59]. The spindles .5-.1.5 seconds and appear with a period of about minute. In some sources frequency range 7-16 Hz is given as sleeping spindle range. The so called K-complexes are sudden increases in EEG amplitude but no change in frequency.

One interpretation is that sleep spindles correspond to the occasional wake-ups of the left hemisphere. Sleep spindles would thus correspond to the satellites of alpha band identifiable as responses of the corresponding Josephson junctions

to occasional strong control signals at cyclotron frequencies in alpha band. K complexes could be interpreted as signals from magnetic body to left hemisphere but inducing no response. It might be that these sudden responses reflect the fact that the left brain is not fully asleep yet.

8.7.3 EEG during stages 3 and 4

Most of EEG power during deep sleep stages 3 and 4 is in the range .75-4.5 Hz [58]. This implies that control signals at cyclotron transition frequencies of ions from the magnetic body cannot be appreciably present and the control signals at cyclotron frequencies of molecular ions, such as DNA with cyclotron frequencies below 1 Hz, should be responsible for the EEG. The small amplitude of control signal implies $1/f_c$ behavior and large amplitude as compared to the corresponding amplitudes at higher bands at weak amplitude limit.

Taking into account the fact that magnetic field strength is scaled down by factor of 1/2 this means that mass numbers of the ions in question must satisfied $A/Z \geq 150$ for $f_c \leq 1$ Hz. For DNA sequences with charge of 2 units per single base-pair one would have $A \geq 300$. The atomic weights for base pairs plus phosphate group and deoxyribose sugar are $327, 321, 291, 344$ corresponding to A, T, C, G. Harmonics would be present also now but their contributions are small if the amplitudes of the control signals are small.

8.7.4 Transcendental states of consciousness and EEG

Transcendental states of consciousness are characterized by the presence of alpha and theta bands [60] (note that theta band is present also during childhood, youth and even early adolescence but usually disappears at older age). It is found that that theta and alpha bands are preserved also during deep sleep [61]. A possible interpretation is that the presence of alpha band signifies that left brain remains awake in a state of relaxed alertness involving weak signals from magnetic body. One could also argue that even deep sleep is a conscious state but that the presence of alpha band activity in left brain is necessary in order to have memories about this state.

8.8 Scaled up EEG periods at levels $k_d = 5, 6, 7$

It of considerable interest to find the scaled up EEG periods corresponding to frequencies $8, 10, 12$ Hz in alpha band and their satellites for levels $k_d = 5, 6, 7$ levels in order to see whether they might correspond to some important bio-rhytms. For $\lambda = 1902$ Josephson periods are given by $T_J = 7.35$ minutes, 9.02 days, and 43.6 years.

T_c/min	4.59	3.66	3.06
$T_+(1)/min$	12.25	7.35	5.25
$T_+(3)/min$	1.93	1.47	1.19
$T_+(5)/min$	1.05	0.82	0.67
$T_-(1)/min$	2.83	2.45	2.16
$T_-(2)/min$	1.27	1.05	0.90
$T_-(3)/min$	0.82	0.67	0.57

Table 7. Periods T_c and $T_\pm(n)$ corresponding to f_c and $nf_c \pm f_J$, $n = 1, 3, 5$ for scaled up EEG at $k_d = 5$ level corresponding to alpha band frequencies 8, 10, 12 Hz of the ordinary EEG. The unit is one minute and Josephson period is 7.35 minutes.

T_c/day	5.6	4.5	3.8
$T_+(1)/day$	15.03	9.01	6.44
$T_+(3)/day$	2.37	1.80	1.45
$T_+(5)/day$	1.29	1.00	0.82
$T_-(1)/day$	3.47	3.01	2.65
$T_-(2)/day$	1.55	1.29	1.10
$T_-(3)/day$	1.00	0.82	0.69

Table 8. Periods T_c and $T_\pm(n)$ corresponding to f_c and $nf_c \pm f_J$, $n = 1, 3, 5$ for scaled up EEG at $k_D = 6$ level corresponding to alpha band frequencies 8, 10, 12 Hz of the ordinary EEG. The unit is one day and Josephson period is 9.02 days. Note that 1 day (24 hours) appears as period.

T_c/y	27.3	21.8	18.2
$T_+(1)/y$	72.7	43.6	31.2
$T_+(3)/y$	11.5	8.7	7.0
$T_+(5)/y$	6.2	4.8	4.0
$T_-(1)/y$	16.8	14.5	12.8
$T_-(2)/y$	7.5	6.2	5.3
$T_-(3)/y$	4.8	4.0	3.4

Table 9. Periods T_c and $T_\pm(n)$ corresponding to f_c and $nf_c \pm f_J$, $n = 1, 3, 5$ for scaled up EEG at $k_d = 7$ level corresponding to alpha band frequencies 8, 10, 12 Hz of the ordinary EEG. The unit is one year and Josephson period is 43.6 years.

8.9 Is $k_d = 3$ level responsible for kHz neuronal synchrony?

The time scale of nerve pulse emission is millisecond and synchronous emission of nerve pulses suggests the existence of a clock with frequency 1 kHz. Also

memetic codeword for which single bit corresponds to 1027 Hz frequency requires a clock at ~ 1 kHz frequency.

The scaled up hierarchy of EEGs indeed predicts 1 kHz frequency band as a scaled up variant of 1 Hz cyclotron frequency associated with DNAs. Suppose that also magnetic flux tubes with area scaling as $S = \hbar^2$ and B scaling as $B \propto 1/\hbar$ are present, at least for sufficiently large values of k_d. For this hierarchy cyclotron frequencies would scale as $1/\hbar$ and for $k_d = 3$ 1 Hz DNA frequency in delta band would scale up to 2 kHz for $Z = 1$ magnetic flux quantization. For $Z = 2$ flux quantization scaled up DNA cyclotron band would be around 1 kHz and could serve as a drum beat making possible synchronized neuronal firing. Similar situation would be obtained for the cyclotron frequencies of singly charged exotic ions for which color bond inside nucleus has become color charged so that cyclotron frequency is typically in or below alpha band scaled down to 5 Hz.

8.10 Generalization of EEG to ZEG

The generalization of the model of EEG to ZEG (E in the middle of EEG could be of course replaced with appropriate letter such as K) is rather straightforward.

Also now there are three contributions: Z^0 Schumann frequencies, cyclotron frequencies, and the frequencies associated with Josephson junctions. The most conservative approach assumes that also Z^0 flux sheets characterized by k_d traverse DNA (that is genes have wormhole contacts with these flux sheets). If these sheets possess the thickness of DNA double strand, the finite range $L_w(k_d)$ of $k = 113$ Z^0 quanta does not pose other restrictions than the requirement that the overall width of flux sheets is below $L_w(k_d)$.

For $k = 113$ weak bosons with $k_d = 2$ one has $L_w \simeq .2$ μm. For $k_d = 4$ which is thermally stable one would have $L_w \simeq .8$ m corresponding to the size scale of the human body, which is by a factor 2^{-22} smaller than the corresponding size in the electromagnetic case. Z^0 magnetic fields satisfy flux quantization condition implying that cyclotron frequency and energy are proportional to $Q_Z/Q_{Z,0}$, where a particle with charge $Q_{Z,0}$ defines flux quantization. Cyclotron frequencies would differ from their electromagnetic counterparts for $k_d = 2$ level only by factors $Q_Z/Q_{Z,0}$. The condition that Z^0 ions are em neutral would mean that Z^0 ions and bosonic ions are in one-one correspondence so that ZEG would be more or less identical with EEG as far as cyclotron frequencies are considered.

The model of Josephson junction hierarchy must be based on guesses. The simplest guess is that the cell membrane involves also a space-time sheet giving rise to Z^0 voltage, which is minimal in the sense that the energy of a singly charged Z^0 ion is at thermally marginally stable and thus also now $\simeq .08$ eV. The hierarchy of Z^0 Josephson junctions would result in an exactly the same manner as in the electromagnetic case and Josephson energies are same for all levels whereas frequencies scale down as $1/\hbar$.

Also the notion of Schumann resonance at same energy range as in em case could make sense. The finite range of weak force implies effectively the presence

of conductive spherical surface analogous to ionosphere at radius L_w preventing the penetration of Z^0 electric field through. Hence the system would possess effective Z^0 Schumann cavity and it could be possible to speak about cavity oscillations. Earth length scale would correspond to $k_d = 6$ level of dark matter hierarchy for Z^0 field which would mean that the Schumann energy would be very large in this length scale, about .64 MeV. $k_d = 4$ level ($L_w = .8$ m) would give Schumann energy which is of the same order of magnitude as in electromagnetic case.

With these assumptions the spectrum of ZEG for $k_d = 4$ level would be very much like the spectrum of EEG. An important difference would come from the fact that simplest exotic ions obtained by the generation of charged color bonds inside nuclei would be singly charged bosons and alpha band would be scaled down to 5 Hz for them. The mass number differs by one unit from that of ordinary ion and the resulting change of cyclotron frequency could be used as an experimental signature of exotic ion. Also Josephson energy would be one half from that of $Z = 2$ satellites so that alpha band its satellites would be suffer exact scaling by factor 1/2. For $k_d = 3$ and Z^0 magnetic field scaled up by λ, the 1 Hz lower bound dictated by thermal stability would correspond to kHz frequency for $Z = 2$ flux quantization. Scaled up delta band might be the "drum beat" making possible neuronal synchronization.

9 How EEG and ZEG relate to conscious experience?

In this section possible interpretation of cyclotron phase transitions and EEG from the point of view of conscious experience are discussed.

9.1 Sensory canvas hypothesis

Sensory canvas hypothesis assumes that magnetic transition frequencies code for the temporal and possibly also spatial positions of the objects of the 4-D perceptive field at the personal magnetic body characterized by field strength B_{end}.2 Gauss at the surface of Earth. Magnetic transition frequencies are associated with MEs serving as sensory projectors to which various sub-selves representing features are entangled.

The view about evolution of consciousness as a gradual emergence of increasingly lower EEG frequency scales suggests a general paradigm concerning the assignment of the frequency bands with various cyclotron frequencies and possibly spin flip frequencies. 40 Hz band could naturally correspond to MEs projecting symbolic representations associated with the sensory input to the magnetic sensory canvas. The range 20-40 Hz could be associated with some simple cognitive features or emotions (say associated with odor discrimination) whereas 13-20 Hz interval could correspond to more refined cognitive features. Alpha and theta bands could relate to the features representing memories. The possibility of communications at theta, delta and alpha frequencies to higher

level many-brained magnetic selves representing collective levels of consciousness must be considered seriously in TGD framework.

The processing of the sensory input involves where-what division. The fact that 'where' aspect has developed earlier encourages to think that it is more primitive aspect of perception so that the EEG frequencies associated with the simplest 'where' aspects might be higher. This is supported also by the fact that the EEG rhythms associated with brain stem and cerebellum correspond to 80 Hz and 200 Hz respectively.

The narrow highly coherent frequency bands with width of order 1-2 Hz reported by Nunez at 3, 5 and 7 Hz, the alpha band at 11 Hz, and the narrow bands at 13, 15 and 17 Hz [74] plus the 8 Hz width band around 40 Hz provide empirical support for the basic assumptions and a good starting point for possible more detailed identifications.

9.2 Magnetic quantum phase transitions, EEG, and ZEG

The original attempt to assign our qualia to magnetic and Z^0 magnetic transitions need not be correct. The following scenario looks a more realistic working hypothesis.

1. The negative energy EEG and ZEG MEs associated with magnetic and Z^0 magnetic transitions serve as quantum entanglers of the bodily mental images to the personal magnetic body. Z^0 magnetic quantum phase transitions for cognitive neutrinos associated with $\nu\overline{\nu}$ wormhole contacts serve as a correlate for conscious hearing: perhaps also magnetic qualia are analogous to hearing. If sensory representations are realized at the personal magnetic body, the magnetic quantum phase transitions at the personal magnetic body contribute to our conscious experience by the fusion of "simple feeling of existence" mental images with much more complex bodily mental images.

2. The field patterns associated with positive energy EEG and ZEG MEs code for declarative long term memories perhaps using the hierarchy of p-adic cognitive codes discussed above. The model of long term declarative memories suggests that bodily magnetic qualia need not be conscious-to-us. The magnetic quantum phase transitions would represent a step in the transformation of the field patterns of EEG MEs representing declarative memories to conscious experiences.

The overall conclusion would be that, as far as primary sensory qualia are considered, magnetic transitions are not very interesting from the view point of our conscious experience. On the other hand, the hypothesis that magnetic fields are such that magnetic transition frequencies tend to coincide with various universal p-adic frequencies, makes them very interesting concerning the practical models for what might be happening at the magnetic flux tubes of body and brain.

9.2.1 Sensory maps by magnetic frequency scale coding

There is a large temptation to assume that the great variety magnetic and Z^0 magnetic transitions in EEG frequency range make possible hierarchy of living maps. A varying magnetic and Z^0 magnetic frequency scale would code for a position of neuron or some larger unit of brain and to which input from a point of perceptive field is mapped by entanglement (sharing of mental images) and/or by classical communications. Personal magnetic body would essentially remember what happens at material body by sending entanglement inducing negative energy ME to brain along magnetic flux tube and receiving positive energy MEs inducing self-organization and generation of mental images. The classical communication would be like communicating selectively by broadcasting radio waves to receivers each having their own narrow radio wave band.

The working hypothesis is that various mental images in the cortex are projected outside the cortex and CNS at the canvases formed by the magnetic and/or Z^0 magnetic flux tubes associated with various body parts. There are good reasons to believe that these maps are realized in the length scales of EEG wavelengths. The resulting 3-dimensionality of the map is a strong argument in favor of these maps as also the complete decoupling between representation and information processing yielding the representation.

Quantum maps could be realized by place coding using magnetic and Z^0 magnetic frequencies associated with ELF MEs emerging radially from various parts of CNS, also from sensory organs even. If the time mirror mechanism is the general mechanism of sensory perception, motor action, and memory applied by the magnetic body, the length along the magnetic flux tube codes for the temporal distance to the geometric past. This coding would rely on resonance mechanism involving also resonant interaction of MEs with Alfven waves associated with magnetic flux tubes (much like oscillations of string). The very slow dependence of these frequencies on distance would be determined by the strengths of the classical magnetic fields for which these flux tubes provide a representation as topological field quanta.

Of course, one can imagine several options. One possibility is that magnetic transitions could be used for the temporal coding of the sensory representations whereas Z^0 magnetic transition could be used for the temporal coding of generalized motor actions. This would obviously help to avoid overlap between signalling associated with sensory representations and motor actions.

Magnetic and Z^0 magnetic quantum phase transitions could give rise to chemical maps of parts of organ. By using appropriate value of frequency, magnetic quantum phase transitions can be induced and the intensities of these transitions would provide conscious measure for the densities of Bose-Einstein condensates of ions (and perhaps even their Cooper pairs if they manage to be thermally stable) whose densities in turn relate to those at atomic space-time sheets by many-sheeted ionic equilibrium conditions. If the thickness of the magnetic flux tube varies different quantum phase transitions occur at different points of the flux tube and kind of conscious spectrogram results. This kind of generalization of NMR spectroscopy need not be conscious to us although

chemical senses could relate to it.

9.2.2 Place coding for the geometric parameters characterizing simple geometric features

Place coding for various geometric parameters characterizing simple geometric 'features' could be realized using the variation of the cyclotron frequency along a magnetic flux tube of varying thickness. The hierarchy of the sensory canvases allows a modular structure in which a geometric feature such as triangle, line, or ellipse represented at a lower level sensory canvas is projected to a *single* point of 'our' sensory canvas. If one accepts that only negative energy MEs can serve as entanglers, the conclusion would be that place coding must utilize negative energy MEs to entangle brainy mental images with the "simple feelings of existence" at the magnetic body.

Becker tells in his book "Cross Currents" [97] about a technique discovered by Dr. Elizabeth Rauscher, a physicist, and William Van Bise, an engineer. The technique uses magnetic fields generated by two coils of wire, each oscillating at a slightly different frequency and directed so as to intersect at the the head of the subject person. When two energy beams with different frequencies intersect at some point in space, a third frequency, so called beat frequency is formed as the difference of the frequencies. What Bise and Rauscher found that this ELF frequency (unfortunately, I do not know what the precise frequency range was) generates simple visual percepts like circles, ellipses and triangles and that the variation of the second frequency induces the variation of the shape of the percept.

The simplest interpretation is that the beat frequency is extracted by non-linear effects in brain and induces a magnetic quantum phase transition at magnetic tubes whose thickness varies and codes for a parameter (say scaling in some direction) characterizing the geometry of the primitive percept (or 'feature'). The proposed general mechanism for how EEG MEs give rise to declarative memories should apply also now and would mean that EEG MEs induce cyclotron transitions giving in turn rise to neural activity. If primary sensory organs are seats of sensory qualia, back-projection to the eyes is involved with the process as also in the case of electric stimulus of cortex inducing visual sensations. The intersection of ELF waves would wake-up symbolic mental images representing triangle and back-projection would make this concept visual. The geometric parameters characterizing the triangle would be coded to frequency differences. An analogous phenomenon occurs also for auditory inputs with slightly different frequencies feeded into ears and makes it possible to 'hear' sounds below the audible range. The mechanism could be the same.

9.2.3 Flag-manifold qualia and magnetic fields

Recall that the flag-manifold representing various choices of quantization axes is a coset space associated with the zero modes. The association of the six-dimensional flag-manifold of color group $SU(3)$ to honeybee dance and geo-

metric aspects of honeybee's sensory experience (described in the chapter [K3] inspired the hypothesis that the values of the flag manifold coordinates might be quite generally mapped to magnetic or Z^0 magnetic frequencies by mapping these coordinates to the parameters characterizing magnetic flux tubes. Thus there are two frequencies involved and the mappings projects everything to 2-dimensional space.

The flag-manifold defined by the choices of the quantization axes for the super-canonical algebra of the configuration space is infinite-dimensional. One can however consider finite-dimensional flag-manifolds as lowest order approximation. In the case of MEs of type $E^2 \times CP_2$, the minimal flag-manifold would be the one defined by the Cartan group of $SO(2) \times SU(3)$, which is just the flag-manifold $F_3 = SU(3)/U(1) \times U(1)$ of color group introduced by Barbara Shipman. For MEs of type $S^2 \times CP_2$ which correspond to spherical light fronts the flag manifold is $S^2 \times F_3$. A very natural identification of S^2 is as labelling orientations of a vector in 3-space. Thus one might consider the possibility that the increments S^2 coordinates could represent changes of orientation at the level of conscious experience. On the other hand, linear sequence of sub-selves inside self would represent experienced orientations very concretely.

One could try to generalize, and consider the possibility that the proper flag manifold is defined by $SO(3,1) \times SU(3)$ by the division by Cartan subgroup. Lorentz group would give 4-dimensional flag-manifold $SO(3,1)/R \times SO(2)$. Lorentz rotations can be decomposed to boosts followed by rotations in rest frame of the resulting system. This suggests that $SO(3,1)$ flag-manifold has a bundle structure with the sphere S^2 defined by boost directions serving as the base and the sphere S^2 defined by the possible directions for the axis of rotation in the rest frame serving as the fiber. Again sub-self moving inside self could represent the direction of boost naturally.

There must be some correlation between the values of zero modes (in particular, flag manifold coordinates) and classical em Z^0 magnetic fields. For instance, color rotation affects the em and classical Z^0 fields. In this sense flag-manifold coordinates can be coded to em and Z^0 magnetic frequencies but the image is 2-dimensional. The work of Barbara Shipman with the dance of honeybee indeed implied that flag-manifold coordinates are mapped to spatial positions in *2-dimensional* plane representing the dance stage. This suggests that $F_3 = SU(3)/U(1) \times U(1)$ coordinates have representational role: they represent concrete geometric information about spatial positions. This representational role could derive from more general assumptions. The positions of plane are represented as frequencies by the place coding by magnetic and Z^0 magnetic frequencies and $SU(3)$ rotations affect em and Z^0 magnetic frequencies so that plane points can be mapped to equivalence classes of $SU(3)$ rotations so that a 2-dimensional space associated with the flag-manifold F_3 emerges naturally.

9.2.4 Could magnetic and Z^0 magnetic phase transitions define sensory qualia?

If universality principle holds true, both magnetic and Z^0 magnetic qualia can be divided to universal kinesthetic qualia and to generalized chemical qualia corresponding to the change of a number of particles in a state with given quantum numbers (say the integer n characterizing cyclotron state). The interpretation of these qualia is far from obvious.

1. Z^0 magnetic qualia could be "universal feelings of existence" associated with the place coding of the motor actions from the sensory canvas and also inside brain. This would mean a neat separation of sensory and motor representations from each other. Universal feeling of existence might also be the basic aspect of tactile senses and in fact, all sensations.

2. If the harmonic of the cyclotron frequency does not affect the character of the quale, the number of cyclotron qualia of both em and Z^0 type is finite. Alpha band is expected to be the most interesting frequency range as far as qualia are considered. The five bosonic ions $Mn^{2+}, Fe^{2+}, Co^{2+}, Zn^{2+}$, and Se^{2-} have cyclotron frequencies 7.6, 9.4, 10.0, 10.8 and 11.4 Hz. The number of basic tastes is thought to be five, which could mean that magnetic cyclotron phase transitions correspond to the basic tastes. The number of odors is definitely larger than basic tastes as is also the number of exotic Z^0 ions, which are almost always bosons. Thus the identification of Z^0 magnetic cyclotron transitions as correlates for odors can be considered.

This proposal can be criticized. Any bosonic molecule with $A/Z \leq 223$ (thermal stability of the BE condensate at room temperature) could as such directly define a cyclotron quale so that tastes and odors would correspond to cyclotron transitions of molecules themselves rather than those of bosonic ions in alpha band. One could also argue that the odors and tastes should have a natural ordering according to the value of cyclotron frequency and be continuously transformable to each other by changing the strength of the magnetic field. This doesn't seem to be the case.

9.2.5 What about Larmor frequencies?

Larmor frequency characterizes the nuclear contribution of this interaction to energy and is related to the cyclotron frequency of a singly ionized atom by

$$\omega_L = g\frac{S}{2}\omega_c \quad , \quad \omega_c = \frac{eB}{m} \quad .$$

where S denotes the maximal projection of spin in the direction of the magnetic field and g is Lande factor, which equals to $g = 1$ in the ideal classical case for which spin corresponds to angular momentum whereas $g = 2$ holds true for elementary fermions. Nuclear contribution is the dominant contribution for ions Na_+, K_+, Cl_- since electron shell is full for the ions in question. The magnetic

moments of ions Cl_-, K_+, Na_+ reduce to their nuclear magnetic moments and are rather large:

$$\mu = x\frac{e}{2m_p}S \ , \quad g \simeq 2xA \ ,$$

where m_p denotes proton mass and x is a parameter of order one so that Lande factor is proportional to the mass number A of nucleus. The reason for large value of μ is that magnetic interaction energy of the nucleus is essentially the sum over the interaction energies of nucleons.

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 interaction of the nuclear spin with magnetic field dominates over the cyclotron interaction energy by a factor of order A and that the natural frequency scale for the ionic Larmor frequencies is hundreds of cycles per second. The values of the parameter x are $x(Na) = 2.214$, $x(Cl) = .82181$ and $x(K) = .3915$. For instance, for Na_+ spin flip transition frequency with $\Delta S = 1$ is $f \sim 222$ Hz. For Ca_{++} spin and magnetic moment vanishes. Note that for $J = 3/2$ ions there are in principle three kinds of transitions corresponding to $\Delta S = \pm 1, \pm 2, \pm 3$. If transition reduces to single nucleon level, $\Delta S = \pm 1$ is the only possibility. The conclusion is that Larmor frequencies probably correspond to different components of sensory modalities than cyclotron frequencies.

The transitions changing the direction of spin of the Cooper pair are induced by the frequencies

$$\omega = (2n+1)\omega_c + 2\Delta m\omega_L = (2n+1+g\frac{\Delta m}{2})\omega_c \ .$$

Odd multiples of the cyclotron frequency are possible in the first order perturbation theory whereas even multiples are possible only in the second order.

The natural question is whether also spin flips to which Larmor frequencies are associated could be also important from the point of view of conscious experience. 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.

Consider now some examples.

1. For proton and neutron the Lande factors are $g(p) = 3.58$ and $g(n) = -3.82$ so that the spin flip transition frequencies in Earth's magnetic field would be $2\omega_L = 542$ cycles/second for proton and 570 cycles/second for neuron. The frequencies $2f_L$ and $2f_L + f_c = 842$ cycles/second could have something to do with the time scale of nerve pulse in case of proton. Note that $2f_L - f_c = 242$ cycles/second is of same order as f_c for proton so that corresponding qualia might resemble each other.

2. For electron $g = 2$ in excellent approximation and the Larmor frequency is very nearly identical with one half of cyclotron frequency. The deviation is

$$\frac{\Delta g}{g} = \frac{\alpha}{2\pi}$$

in the lowest order of perturbation theory ($\alpha \simeq 1/137$) and thus the frequency for the transition $(n+1, up) \leftrightarrow (n, down)$ changing the spin direction of the second electron of the Cooper pair is $\omega \simeq 902$ Hz. This time scale corresponds to the duration of memetic codon fixed by the fact that memetic code corresponds to Mersenne prime M_{127}, which happens to be the p-adic prime characterizing also electron.

3. Spin flip frequencies for atomic nuclei are in general of order few hundred Hz for $B = .2$ Gauss. For instance, the spin flip frequencies of Mn, Co, Cu, and Na are for $B = .2$ Gauss 228 Hz, 199 Hz, 223 Hz, and 222 Hz. What makes this interesting is that cerebellar resonance frequency is around 200 Hz.

The eight ions listed in the table below 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 super-canonical 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.

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

Table 10. 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 $f_{min} = 2f_L/J$m, where J is nuclear spin. Ag allows two stable isotopes with almost same abundances and the values of f_{flip} are given for both.

Magnetic states have momentum in the direction of the magnetic field and a priori the transition frequency spectrum is continuous rather than discrete. Energy and momentum conservation however imply that the increment of longitudinal momentum is fixed in transition and in excellent approximation transition energies are equal to those obtained by neglecting longitudinal momenta altogether.

To get an idea about energy and momentum transfers involved with the transitions between magnetic states with longitudinal momenta k_1 and k_2, one one apply energy and momentum conservation by assuming that the classical field associated with ME, and thus propagating with light velocity, induces the transition. Let k_1 and k_2 denote the wave vectors of initial and final magnetic states in the direction magnetic field: the corresponding contributions to the energies of the magnetic states are $k_i^2/2m$, $i = 1, 2$. Let $k_{||} = kcos(\theta)$ denote the projection of the wave vector k of the ME em wave to the direction of the magnetic field satisfying $k = E$: momentum conservation gives $k_1 - k_2 = k_{||}$. Energy conservation in turn gives

$$\Delta E = \Delta E_B + (k_1^2 - k_2^2)/2m = E \ ,$$

where

$$\Delta E_B = n\omega_c + \omega_{flip}$$

denotes to the contribution of the cyclotron and spin flip components to the transition frequency. The condition

$$(k_1 + k_2)/m << 1$$

is certainly satisfied and this allows the approximations

$$k = \Delta E \simeq \Delta E_B$$

$$k_1 - k_2 \simeq \Delta E_B cos(\theta)$$

The result means that transition frequencies are not essentially affected by the energy transfer in longitudinal degrees of freedom and it is an excellent approximation to assume that the frequencies inducing magnetic transitions correspond to the transition frequencies associated with the transitions in cyclotron and spin-flip degrees of freedom.

9.3 Altered states of consciousness and EEG

The magnetic flux tubes in the length scale range determined by theta and delta band could quite well connect magnetic body to several different organisms and make possible sharing of experiences. Also magnetosphere and even larger magnetic structures could give rise to sensory and other representations receiving input from several organisms and sharing of mental images would allow to share these experiences.

If magnetic body is the experiencer applying time mirror mechanism and if positive energy EEG boundary MEs in delta and theta bands correspond to classical communications of declarative memories usually not conscious-to-us, the dominance of theta and delta waves during sleep suggests two alternatives.

1. During the sleep our attention is directed to transpersonal levels of consciousness but that we do not remember anything about this. The reason might be that no declarative memories are generated during this period.

2. We are entangled with transpersonal levels of consciousness and have lost our personal consciousness. A conscious contact with transpersonal levels requires sharing of mental images with these levels and this might occur during meditation. Theta and delta bands are also known to dominate during deep meditation.

One can consider two alternative interpretations corresponding to interior MEs (phase velocity equal to light velocity) and positive energy boundary MEs (phase velocity equal to EEG phase velocity) associated by scaling law with the negative energy MEs.

1. For positive energy interior MEs the frequencies would correspond to magnetic flux tube lengths up to about 10 Earth circumferences and contained within Earth's magnetotail at the night side. Time scale would be $T = 1/f$. These MEs could feed data using appropriate cognitive codes at p-adic resonances frequencies to the magnetospheric multi-brainy collective selves responsible for the transpersonal levels of consciousness.

2. The scaling law, assuming the alpha wave phase velocity to be the effective phase velocity v of boundary ME, would predict that the time $T_1 = \lambda/v$ needed by the boundary MEs to travel the distance $L = c/f$ defining the distance to the point of the magnetic body wherefrom the negative energy EEG ME was sent to the brain, is measured using decade as a natural unit. If magnetic body is the experiencer applying time mirror mechanism this would mean that delta band would correspond to memories with time span of about ten years. One might think that the magnetic body triggers boundary MEs using negative energy MEs in ULF range which automatically give rise to memories experienced after time T_1.

9.3.1 Transpersonal levels of consciousness

Individual organisms or even larger structures could define the 'pixel size' for higher level multi-brained selves realized as sensory, symbolic and cognitive representations at various magnetic structures like the magnetosphere of Earth. These levels could correspond to any p-adic length scale above brain size. These levels would obviously represent the consciousness of various kinds of groups and collectives.

1. *Sleep and transpersonal states of consciousness*

The simplest assumption is that one loses consciousness during sleep by entanglement with some higher level self, say magnetospheric multi-brained self. This would give rise to a fusion of mental images at this higher level and to a stereo consciousness representing "human condition".

One should not be however too hasty to make this kind of conclusion. If it is indeed biological body which sleeps, our field body could be full awake with attention directed to transpersonal levels of existence. If this is indeed the case, the basic question would be about how to have these experiences and simultaneously form long term declarative memories about them: some part of brain, probably including hippocampus, should be kept awake during these experiences. Perhaps meditative states, often characterized as transpersonal ego-free consciousness, are this kind of states.

2. Who am I?

These arguments raise the question 'Who am I really?'. What precise length scale my ME does corresponds size of Earth, of solar system, of galaxy? Or can my self size be literally infinite and correspond to some infinite p-adic prime and is only the localization for the contents of my conscious experience to this particular corner of this particular galaxy which creates the illusion that I am this biological body? During episodal memories and also ordinary memory recall parts of magnetic body and MEs having size $L = cT$, T the time span of the episodal memory are actively involved so that one can say that the size of "me" is measured in light years. But it is difficult to say whether the contents of my consciousness contains only personal memories even in ordinary states of consciousness. For instance, it is difficult to locate mathematical ideas in any particular portion of space-time and p-adic space-time sheets which are infinitesimally small p-adically are infinitely large in real sense.

Whatever the detailed answer to these questions is, this view allows to interpret physical death as a re-directed attention and giving rise to what might be called re-incarnation. What would differentiate between my and my dog's soul that our attentions are differently directed.

3. Examples of transpersonal experiences

Near-death experiences and out-of-body experiences could be examples of of almost transpersonal, 'ego-free' consciousness. That these experiences often involve the experience of seeing one's own body from outside, is consistent with the transpersonal nature of the experience. As already noticed, delta band is peak frequency in the EEG of infant, which would suggest that children either direct their attention mostly to the transpersonal levels or that children are strongly entangled and almost unconscious as also we are when theta and delta bands of EEG dominate. That this would be the case would conform with the ideas about bicamerality. Otherwise our personal development would be gradual spiritual degeneration.

The experiences of what I call whole-body consciousness could also be example of consciousness involving transpersonal component. These states appear often at night time as dream like experiences and involve illusion of being in

ordinary wake-up consciousness. The usual 'noise' present everywhere in body, possibly due to the averaging over proprioceptive experiences of sub-selves, disappears totally and peculiar silence falls down. Whole-body consciousness starts as a stir in spine (same as generated by good music sometimes) extending gradually to the entire body. Experiences of weightlessness and of 'wavy' nature of physical body, flying into roof and falling down smoothly back into bed are typical aspects of these experiences. During this kind of experience it is sometimes also possible to leave the room. During my 'great experience' I experienced of leaving the hospital and walking along street knowing that I was invisible. This experience ended to experience of being brought back to hospital by hospital personnel.

Short lasting form of whole-body consciousness is also possible after waking-up immediately after falling asleep in daytime: perhaps theta consciousness prevails for a short time after wake-up. My personal 'great experience' involved besides whole body consciousness enhanced cognition: entire flux of ideas many of which have later developed to basic principles of quantum TGD.

9.3.2 Meditative states of consciousness and EEG

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The proposed general picture allows to build a rough model for the mechanism leading to meditative states. One can also understand how so called ORMUS elements [116] might help to achieve these states.

The harmonics of cyclotron frequencies in delta band should represent even more deeper transpersonal qualia with time scale of about $t_1 = (c/V) \times T$, $T = 1/f$ light years for $f = 1.5$ Hz and $V = 3$ m/s. One could of course argue that the concentrations of heavy ions in brain are so low so that corresponding cyclotron transitions do not give rise to any experiences even if scaling law would not forbid them. This objection is not necessarily very convincing since the needed densities of ions in cellular space-time sheet might be by a fraction of order $[L(137)/L(167)]^3 \sim 10^{-13}$ smaller than density of water and because heavier ions are in gas form and presumably tend to be mostly in non-atomic space-time sheets. TGD predicts also new electro-weak physics would could dramatically change the isotope ratios at cellular space-time sheets.

Delta waves might relate to the interaction of brain with sferics which are atmospheric em perturbations [21]. The spectrum of sferics at delta frequencies resembles EEG spectrum at same frequencies [21]. The electric fields associated with sferics are of same order of magnitude as waves in delta band so that they are not amplified as much as alpha waves. This could explain why delta and theta consciousness is so weak.

One could also consider enhancing delta consciousness artificially: perhaps this could make enlightment experience, if not more probable, at least more intense. This could perhaps be achieved by feeding in brain some heavy singly ionized ions with cyclotron frequencies in delta band and stimulating brain using ELF em field at corresponding cyclotron frequency in $B_{end} = 0.2$ Gauss. Some candidate ions are $Ag^+ : f_c = 2.8$ Hz; $I^+ : f_c = 2.4$ Hz and $Au^+ : f_c = 1.5$

Hz. Also heavy ions like Hg and Pb are in the same frequency range as Gold. For $Z = 1$ flux quantization these frequencies are halved since magnetic field strength is halved.

There are claims for so called ORMUS atoms which somehow differ from ordinary atoms [116]. The persons involved take doses of what they call ORMUS elements, in particular so called White Gold, to induce spiritual experiences. In fact, Barry Carter who wanted to understand what is involved, contacted me about five years ago and told about these effects and I ended up the notion of wormhole Bose-Einstein condensate as a possible explanation of the claimed properties of White Gold. It might be that Gold ions and other heavy element ions enhance transpersonal sensory consciousness in delta band and lead therefore to spiritual experiences.

There is also a patented process developed by Robert Monroe and called Hemi-Synch [62] which might induce delta and theta consciousness. Feeding audible sounds to ears with carrier frequencies below kHz and frequency difference of say 10 Hz, which is as such not audible, generates binaural beat involving appearance of an EEG wave at difference frequency [63]. The difference frequency is not only 'heard' but binaural beats in delta and theta range tend to induce relaxed, meditative and creative states [62]. This method might provide a test for the hypothesis that linear combinations or p-adic frequencies are crucial for consciousness by choosing beat frequencies equal to these frequencies. In a similar manner one could test the alternative hypothesis that cyclotron frequencies are fundamental for consciousness. One should know the precise value of local magnetic field and also take into account the possibility that brain could be able to regulate the value of the local magnetic field to some extend. It could be also possible to apply EEG biofeedback and delta and theta frequencies.

9.3.3 Empirical evidence for transpersonal levels of consciousness

Recall that hyper-genes would correspond to flux sheets traversing through cell nuclei belonging to several organisms. Obviously this level would correspond to a transpersonal level of consciousness: kind of multi-brained conscious entities receiving sensory input from several organisms and performing intentional control over their behavior would be in question. Strong correlations between EEGs of individuals, in particular those having a close personal relationship, would be the obvious implication.

The experiments of Mark Germine [76] provide evidence for the notion of transpersonal conscious entities and associated collective memory perhaps realized in terms of flux sheets traversing the neuronal nuclei of several persons. What was studied was the evoked EEG response to a series of random quantum stimuli which consisted of series of identical sound stimuli with randomly located deviant stimulus. Two subject persons, A and B, were involved. In the case that A observed the differing stimulus 1 second before B, the evoked EEG response of B became incoherent. Since evoked stimulus was oscillation at EEG frequency of about 11 Hz in the case that A had not observed the stimu-

lus, one could understand the mechanism as a direct evidence for transpersonal conscious entity interacting with brains of both A and B. When transpersonal conscious entity had hear the stimulus once, it did not react to it in similar manner.

9.4 EEG and Golden Mean

Dan Winter has reported [115] that in certain altered states of consciousness (described as experiences of bliss) the ratio of beta and alpha peaks approaches Golden Mean $\Phi \simeq 1.618...$ It is interesting to look what TGD based model for EEG could say about this finding.

1. For $f_J = 5$ Hz and $f_c = 10$ Hz (the p-adic frequency corresponding to the secondary p-adic time scale $T_2(127)$ associated with Mersenne prime M_{127}, and identifiable as a fundamental biorhythm) one has $\beta/\alpha = 3/2$ which is the lowest approximation to Golden Mean in terms of ratios of Fibonacci numbers. The higher approximations approach to Φ. The approximation sequence would be consistent with the 1 Hz width for the narrow beta bands.

2. This would suggest that beta/alpha ratio is maximal in this state and approaches to Φ in a discrete manner. The question is whether the resting potential is quantized in terms of ratios of Fibonacci numbers $F_{2n}/F_{2n-1} \in \{3/2, 8/5, 21/13, ..\}$. At the limit theta peak would approach to 3.92 Hz: note that shamanic drumming rhythm corresponds to 4 Hz frequency. This hypothesis is testable by comparing possible changes in the measured resting potentials with subjective reports of meditators.

3. The sequence of ratios of F_{n+1}/F_n approaches Golden Mean in an oscillatory manner, which suggests that states of hyperpolarization following generation of nerve pulse correspond to ratios $F_3/F_2 = 5/3$, $F_8/F_5 = 13/8$,... above Golden Mean. In the sate of "full bliss" there would be no hyperpolarization after the generation of nerve pulse. A possible interpretation is that there is no "dead" time after nerve pulse and system is immediately in a state of maximal possible alertness. On the other hand, the state of pure bliss should be ideally a state of pure alertness without mental images. In the state in which cell membrane in resting state is maximally hyperpolarized, nerve pulse generation does not occur too easily and thus sensory or other mental are not easily generated.

4. The sequence of Fibonacci numbers could relate to a hierarchy of finite-dimensional approximations for Jones inclusions for quantum phase $q = exp(i\pi/5)$ represented in terms of braids. $n = 5$ is also the minimal value of n allowing universal topological quantum computation [E9]. The state of full bliss would correspond to the limit at which the number of strands of braid is infinite so that topological quantum computations resources are maximal.

5. Dan Winter has also emphasized the importance of tedrahedral and icosahedral symmetries for DNA. These symmetries correspond to the only genuinely 3-dimension finite subgroups of rotation groups and are symmetries of water molecule clusters. Icosahedral group has $n = 5$ and would allow universal topological quantum computation.

9.5 Pineal gland, EEG and ZEG

Pineal gland is an unpaired structure and strictly speaking not part of brain being located outside the brain in primitive vertebrates. Pineal gland is known to play a role in the control of both central nervous system, endocrine system and immune system [64]. There is also strong evidence that pineal gland forms part of the magnetic navigation system in birds, and possibly also in humans who also have this system. Pineal gland is biological timekeeper and responsible for 24-hour circadian rhythms via a secretion of hormones, in particular melatonin. What pineal gland does is to inhibit secretion whereas pituitary gland facilitates it. Pineal melatonin level controls the hormone secretion and sleep wave cycle and magnetic exposure changes pineal melotonin secretion [64].

What makes pineal gland interesting is that it is accompanied by 10 Hz rhythms. This rhythm corresponds to the strongest resonance frequency in the alpha band for both EEG and ZEG.

9.5.1 Pineal gland as timekeeper

10 Hz corresponds to the p-adic frequency $f(2, 127)$ associated with the 126-bit memetic code, which is an especially important code in the hierarchy of the cognitive codes. The fact that tiny electric field at average alpha frequency of 10 Hz restores biorhythms in absence of local magnetic field [77], suggests that pineal gland has a coupling to some cavity resonances or some magnetic transition frequency equal to 10 Hz.

1. The lowest Schumann frequency 7.8 Hz is too low. On the other hand, the resonance frequency associated with effectively two-dimensional excitations of em fields inside Schumann cavity is exactly 10 Hz and could be involved with the realization of the memetic code.

2. Fe^{++} ion appears naturally and has cyclotron frequency of 10.74 Hz and provides a natural candidate for a biological clock, not necessarily associated with the pineal gland. A 3 per cent reduction of the Earth's magnetic field from the nominal value of .5 Gauss would reduce the cyclotron frequency to 10 Hz.

3. Co^{++} cyclotron frequency would be 10 Hz for $B = .5$ Gauss. Co^{++} has very high nuclear spin and is therefore a natural magnet: Yarrow has indeed suggested that vitamin B_{12} containing Co makes pineal gland magnetic hormone and fundamental biological clock at 10 Hz frequency [77]. Thus at least ELF ME with Co^{++} cyclotron frequency should go through

pineal gland. In the case that they are singly ionized $n = 2$ multiples of corresponding cyclotron frequencies would be involved with the biological clocks in question: these transitions are possible in the second order of perturbation theory.

In darkness 24-hour circadian rhythm changes to 25-hour rhythm perhaps defined by the rotation of Moon and Earths's own rotation. The ratio of 24-hour period to 25-hour period is .96. The ratio of the average of Co^{++} and Fe^{++} frequencies to Fe^{++} frequency is .964 giving period of 24 hours 53 minutes if the average period is 24 hours. This observation suggests that circadian period is measured during daylight in time unit given by the period of Fe^{++} rhythm possibly associated with some visual pathway, perhaps even with eyes, and in darkness by the slightly slower Co^{++} rhythm associated with the pineal gland. Under this assumption the ordinary circadian rhythm f is weighted average of Fe^{++} and Co^{++} rhythms:

$$f = xf(C0^{++}) + (1-x)f(Fe^{++}) \ ,$$

In ideal circumstances circadian rhythm is 24 hours: this gives $x = .44$ with roughly 13.5 day hours and 10.5 dark hours. In continual darkness the rhythm would transform to the slower Co^{++} rhythm of 25 hours with $f = f(Co^{++})$. These two rhythms would presumably distinguish between sleep and awake since pineal gland closely related to the regulation of sleep-wake cycle.

The deviation of x from ideal value $x = .44$ could be an important factor in some disorders. It is known that human melatonin levels do not depend very strongly on season except in arctic latitudes (seasonal affective disorder) but that melatonin levels affect sleep-wake cycle. Abnormally high activity of pineal gland is associated with the hallucinatory periods of schizophrenia: perhaps visual hallucinations of schizophrenic are partially mediated by pineal gland. The manic (depressive) phase of bipolar disorder correlates also with over- (under-) activity of the pineal gland [64]. Keeping x by artificial lighting near its ideal value could be of help. The artificial modification of the strength of the local magnetic field should modify the unit of biological time: perhaps this could provide a manner to cure not only jet lag but even much more serious mental disorders.

9.5.2 Pineal gland as "third eye"

The question is whether the 25-hour rhythm equals to the rhythm defined by moon's rotation or is it a mere coincidence. If not, then the MEs going through through pineal gland might mediate unconscious-to-us information about the rotation of Moon. Could higher level self 'see' moon in its orbit? Perhaps in some sense! The ability to restore circadian rhythms is based on the photosensitivity of the pineal gland. Pineal gland has been indeed regarded as "third eye" by mystics. As a matter fact, in some lower vertebrates pineal gland serves as a genuine eye [65]. For long it has been thought that in mammals pineal gland is not (or perhaps cannot be!) directly photosensitive. Indeed, there is a pathway

from the retinas to the hypothalamus called the retinohypothalamic tract [65]. It brings information about light and dark cycles to a region of the hypothalamus called the suprachiasmatic nucleus (SCN). From the SCN, nerve impulses travel via the pineal nerve (sympathetic nervous system) to the pineal gland. These impulses inhibit the production of melatonin. When these impulses stop (at night, when light no longer stimulates the hypothalamus), pineal inhibition ceases and melatonin is released. The pineal gland is therefore a photosensitive organ and an important timekeeper for the human body.

The belief that pineal gland receives information about changes in the lighting from retinas only, has turned to be wrong: mammals lacking ordinary rods and cones genetically, can preserve they circadian rhythms [65]! Thus pineal gland must perceive changes in lighting somehow. TGD based explanation for pineal vision is based on the many-sheeted space-time concept and ELF selves: light reaches pineal gland via MEs associated with EEG frequencies. Why we do not then see with our third eye? Or do do we actually see?: perhaps visual dreaming involves also seeing with the third eye providing 'spiritual input'! This hypothesis can be tested by checking whether the dreams of people with pineal gland injury somehow change. This explanation also suggests that also eyes are foci of converging MEs so that eyes would be rather concretely mirror of the soul!

9.5.3 Perhaps Descartes was not so wrong after all!

Descartes has been ridiculed for his belief that pineal gland is the seat of soul. Perhaps this sentence has been precipitate as suggested by a clinical case in which over-activity of 5-year old child had led to premature adolescence. Here is a fragment from Frederic Tilney's book 'The Pineal Gland':

Until a few decades ago scant attention was paid to the pineal gland. Then came the case, noted by Dr. Berman, in which a child was brought to a German clinic suffering from eye trouble and headaches. He was five years old and very mature, and apparently had reached the age of adolescence. He was abnormally bright mentally, discussing metaphysical and spiritual subjects. He was strongly group-conscious and only happy when sharing what he had with others. After his arrival at the clinic, he rapidly grew worse and died in a month. An autopsy showed a tumor of the pineal gland.

Pineal gland is one of so called chakras in mystic teachings and it is known that pineal gland is involved with altered states of consciousness [64]. Meditation practices assign to third-eye meditation development of "light in the original cavity or center of spirit" located in the center of the brain and "waking of Kundalini" is associated to pineal gland [64].

The fractal hierarchy of the magnetic flux tubes corresponds to a hierarchy of selves and pineal gland is known to contain magnetic crystals. These crystals create magnetic fields which are much weaker than Earth's magnetic field. Their flux tubes, with thickness measured in centimeters, could thus be carriers of super-conducting BE condensates with cyclotron time scale measured in the range year–thousand years. These higher level magnetic selves together with

corresponding MEs could be responsible for the higher levels of the self hierarchy. One could perhaps understand also the various characteristics of near death experiences in terms of higher level magnetic consciousness [I3]. Thus Descartes could have been right after all!

10 Great vision about biological evolution and evolution of brain

The following great vision about evolution and is not perhaps strictly about hierarchy of EEGs. The hierarchy of dark matter and EEGs however leads to this vision naturally. The first part of vision relates to biological evolution. Second part is about the evolution of brain. Here the key thread is evolution of two kinds of intelligences, the ordinary fast intelligence evolving via the emergence of fast computation type activities and emotional slow intelligence developing via the emergence of higher levels of dark matter hierarchy. The latter intelligence is what distinguishes us from animals.

10.1 Dark matter hierarchy and big leaps in evolution

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

There are two hierarchies involved with the dark matter hierarchy. The dark levels associated with weak bosons for which $k_W = 1$ corresponds to the p-adic length scale about $L_W(1) \sim 1$ Angstrom with exotic weak bosons corresponding to $k = 113$ (rather than $k = 89$ as for ordinary weak bosons). There is also electromagnetic dark hierarchy and in a given length scale one has $k_W = k_{em}+2$. In a given scale weak sector would be ahead in evolution by two units so that weak dark bosons can be associated with more abstract functions like cognition and planning whereas em level would be related to simpler functions.

Ordinary matter corresponds to $k_W = k_{em} = 0$ and ordinary value of $\hbar$ and higher levels correspond to scaled up values of $\hbar$ with scalings λ^k, $\lambda \sim 2^{11}$. This mean scaling up of various quantum length scales and also the sizes of space-time sheets by λ. It seems that magnetic flux quanta are the primary structures forming hierarchy of this kind and large $\hbar$ means that cyclotron energy scales expressible as $E = \hbar(k)eB/m \propto \lambda$ so that an arbitrarily weak magnetic field strength can in principle correspond to a cyclotron energy above thermal threshold at room temperature.

The appearance of space-time sheets zoomed up in size by a power of λ means the emergence of new levels of structure and it is natural to identify big leaps

in evolution in terms of scaling of $\hbar$ by λ and emergence of new large magnetic flux sheets satisfying magnetic flux quantization condition with the unit of flux scaled up by λ. This leap is quantum leap but in different sense as thought usually. The emergence of higher dark matter levels would basically mean the integration of existing structures to larger structures. A good metaphor are text lines at the pages of book formed by magnetic flux sheets whose width is scaled up by λ as the new level of dark matter hierarchy emerges.

The big leaps can occur both at the level of organism and population and organisms with rather low individual dark matter level can form societies with high dark matter levels and high collective intelligence (honeybees and ants are good example in this respect).

This conceptual framework gives rather strong guidelines for the identification of the levels of evolutionary hierarchy in terms of dark matter hierarchy. The outcome is a detailed vision about big evolutionary leaps.

1. Molecular life

Magnetic body with $(k_W, k_{em}) = (1, 0)$ corresponds to the lowest level of hierarchy with the size of the basic structures corresponding to atomic length scale. The anomalous properties of water would be partly due to the presence of this level. At least the simplest bio-molecules regarded as living organisms would correspond to this level.

2. The emergence of prokaryotes as simplest membrane bounded structures

At $(k_W, k_{em}) = (2, 0)$ level high T_c superconductivity predicting the basic length scales characterizing the double layered cell membrane, the size scale of the cell, and the weak length scale $L_w(2) \simeq .3$ μm. Prokaryotic cells (bacteria, archea) without cell nucleus and other cell organelles would correspond to this level. Cell nuclei, mitochondria, and other membrane bounded cell nuclei would have evolved from prokaryotes in this framework. Also viruses and nannobacteria could correspond to this level of hierarchy. Cell membrane is responsible for metabolic functions and genome is scattered around the cell at this stage.

2. The emergence of cells having organelles

The appearance of magnetic bodies with $(k_W, k_{em}) = (3, 1)$ correlate with the emergence of simple eukaryotic cells, in particular plant cells. Cell nucleus would be the brain of the cell, mitochondria would be the energy plant, and centrioles generating microtubules would define the logistic system. Also other organelles such as Golgi apparatus, ribosomes, lysosomes, endoplasmic reticulum, and vacuoles would be present. These organelles plus would form a symbiosis by topologically condensing to $(k_W, k_{em}) = (3, 1)$ magnetic body controlling their collective behavior. Centrosomes associated with animal cells would not be present yet but microtubule organizing centers would already be there.

The recent observations show that centrioles are not always in the characteristic T shaped conformation. Daughter centrioles resulting during the replication of mother centriole use first ours of their lifetime to roam around the cell

before becoming mature to replicate. The interpretation would be that they are also life forms and magnetic body utilizes daughter centrioles to perform some control functions crucial for the future development of the cell. For instance, centrioles visit the place where axonal growth in neurons starts.

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

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

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

Receptor proteins would communicate cell level sensory input to the magnetic body via MEs parallel to magnetic flux tubes connecting them to the magnetic body. We ourselves would be in an abstract sense fractally scaled up counterparts of receptor proteins and associated with dark matter iono-lito Josephson junction connecting the parts of magnetosphere below litosphere and above magnetosphere. The communication would be based on coherent photons and weak bosons of generalized EEG associate with the level of dark matter hierarchy in question. The mysterious bio-photons could be decay products of dark photons resulting via de-coherence meaning that the size of the dark photons is reduced in stepwise manner by factor $1/\lambda$ in single step.

3. The emergence of organs and animals

The emergence of magnetic bodies with $(k_W, k_{em}) = (4, 2)$ leads to the formation of multicellular animals. Magnetic body at this level gives rise to super-genome making possible genetic coding of organs not yet possessed by plant cells separated by walls from each other. The super structures formed from centrosomes and corresponding microtubuli make possible complex patterns of motion requiring quantum coherence in the scale of organs as well as memories about them at the level of organs.

4. The emergence of nervous system

$(k_W, k_{em}) = (5, 3)$ magnetic body makes possible nervous system. The period of Josephson oscillations associated with the scaled up variant of cell membrane is about 10 kHz and is consistent with the characteristic millisecond time scale of nerve pulse activity. Nerve pulse reception involves communication to the magnetic body via receptors of the neuronal membrane and the reaction of the magnetic body possibly generating a nerve pulse sequence. Charge entanglement made possible by W MEs makes possible nerve pulse generation as a quantum coherent process.

The emergence of the new level means also the integration of axonal microtobuli to text lines at the magnetic flux sheets making possible logistic control at the multineuronal level. The conformational patterns of the microtubular surface would code nerve pulse patterns to bit patterns representing declarative long term memories. An interesting question is whether the reverse coding occurs during memory recall.

5. The emergence of vertebrates and EEG

$(k_W, k_{em}) = (6, 4)$ magnetic body would bring in EEG possessed by vertebrates and also ZEG and WEG. Magnetic body is now of order Earth size. Natural time scale for the moment of sensory consciousness is measured as a fraction of second and basic building blocks of our sensory experience correspond to a fundamental period of .1 seconds.

6. Cultural evolution

Higher levels in the hierarchy would correspond mostly to the evolution of hyper-genome coding for culture and social structures. Introns are good candidate for the genes involved. The development of speech faculty is certainly a necessary prerequisite for this breakthrough.

10.2 Could insect colonies have "EEG"?

The hypothesis that only vertebrates (having EEG) corresponds to $k_{em} = 4$ whereas insects would have $k_{em} = 3$ is only a hypothesis consistent with the empirical findings about the effects of ELF em fields on vertebrate brain. These findings do *not imply* the hypothesis. Indeed, the situation need not be so simple as the hypothesis suggests in the case of social insects forming colonies. Indeed, ELF magnetic field and magnetic fields affect the behavior of honeybees just as ELF em fields affect the behavior of vertebrates [100]: the model for this findings led to a model for the fractal hierarchy of EEGs.

It seems safe to assume that insect brain is so simple (in the case of honeybee the number of neurons 1/1000 of number of neurons in human retina) that it is not possible to assign $k_{em} = 4$ to it: this would also mean "personal" EEG not possessed by honeybees. The fact that a honeybee isolated from colony dies just as does the cell separated from organism, suggests that the relationship of insect to colony is like that of a cell to organism. Hence one could test whether colonies

of social insects or their sub-colonies might possess an analog of ordinary EEG. What this would mean that ant colonies have sufficiently complex hyper-genome making possible collective variants of memory, sensory input, and intelligence, as well as the ability to realize collective motor actions. Even bacterium colonies have intricate social structures [105] so that one must remain open minded.

10.2.1 Do honeybees have long term memory?

The realization that insect colonies rather than insects might correspond to higher $k_{em} > 3$ levels of the dark matter hierarchy came via an indirect route. The article "Why honeybees never forget a face?" of New Scientist [98] described evidence supporting the view that that honeybees might possess long term memory in the time scale of days.

Adrian Dyer of the University of Cambridge and colleagues trained honeybees to associate a sucrose drink with a photograph of a particular face. The insects were then tested on their memory and recognition skills by being presented with the picture of this face and the pictures of three other faces not associated with any reward. Of the seven bees tested, two lost interest in the trial and flew away. But the five remaining bees correctly identified the target face in more than 80 per cent of trials, even though the reward had been removed. Moreover, some bees remembered the face two days later, indicating that they had formed a long-term memory of it.

The conservative explanation is that the achievement is due to keeping the face-honey association intact in the absence of the stimulus which created it in a time scale of days. For this option the ability of honeybee to express the distance and orientation to the food source could be hardwired involving no conscious memory about the flight. Also the interpretation of the honeybee dance telling the distance and orientation of food source to advices where to fly would be completely "instinctive".

A more radical option is that honeybee hive rather than honeybee has long term memories in the sense as long term memories are interpreted in TGD framework: that is as communications with the geometric past. In this case the span of long term memories is determined by the level of dark matter hierarchy as time $T(k_{em})$ and few days span for long term memories forces the conclusion $k_{em} \geq 6$. For $k_{em} = 6$ level of the dark matter hierarchy the basic "drum beat" defined by the corresponding Josephson frequency (counterpart of 5 Hz frequency in EEG) corresponds to 9 days.

One can ask whether the ability of honey bee queen to found a new honeybee colony could involve long term memory in an even longer time scale $T(k_{em} = 7)$. If this were the case, the queen would not face her formidable challenge alone: the former colony in the geometric past still exists as a conscious entity and could communicate advices to the queen. $k_{em} = 7$ is perhaps an un-necessarily strong an assumption since the magnetic body of the former colony presumably exists also in the geometric now, being physically associated with the queen. This magnetic body could serve as the conscious entity communicating to the queen the advices and commands making possible to construct the beehive. A

more conservative explanation is that these activities are genetically hardwired and instinctive (leaving open what this statement really means).

The distinguished social position and anatomy of queen are consistent with the hypothesis that queen has more massive connections than other bees with the magnetic body of beehive. For instance, it is known that the new hive is oriented in exactly the similar manner as the old. Either long term memory or passive magnetic coding of the orientation of the hive with respect to Earth's magnetic field made possible by the magnetite in the abdomen of queen could explain this.

$k_{em} = 6$ implies that also the levels $k_{em} = 4$ corresponding to ordinary EEG and $k_{em} = 5$ corresponding to short term memory are present. The colony would have sensory resolution in a time scale of a fraction of second and short term memory in minute time scale. The counterpart of EEG at the level of hive is highly suggestive and conforms with the finding that ELF magnetic fields with strengths in the range .1-1 mT ($2B_E - 20B_E$ affect honeybee dance [100] as does also the absence of Earth's magnetic field. Interestingly, 1-2 mT DC field causes epileptiform activity in the case of humans [101] (the change of the DC field used seems to be more important that the period it is applied). Could the beehive suffer a kind of epileptic seizure!

The intentional actions of the honeybee colony would be realized via magnetic flux sheets traversing the super-genes of the insects participating to the action in question. Workers, soldiers, etc.. would act to some extent as organs of the colony being connected by hyper-genes of hyper-genome to larger units. Queen could act as the analog of a complex Grand Mother neuron in brain or a leader in human society.

This view can be criticized. Honeybee dance [102] is performed by forager bees and the dance represents among other things the angle between the lines connecting hive to the food source and sun as the angle between movement of bee and vertical direction (also other options are possible). The intricate pattern of the dance in turn codes for the distance to the food source. If beehive is a conscious entity using bees as its cells, why is honeybee dance needed at all? TGD based vision about the evolution of modern human society from a bicameral society in which individuals received advice and commands from "God" [N6, N5], suggests an answer to this criticism. The society able to survive must be maximally flexible and allow maximal individual intelligence and maximal freedom of individual actions consistent with the overall goals. This requires delegation of simple tasks to lower levels meaning also that communications between individuals become necessary (the development of language and other communications parallels the transition from bicamerality to modern society in the case of humans). The communication itself might however involve also the beehive. Foreagers could be like the prophets of the bicameral society communicating in semitrance the advices of God to the colony.

It should be noticed in passing that honeybees have already earlier made a visit to TGD inspired theory of consciousness [K3]. As discovered by topologist Barbara Shipman [16], honeybee dance has a mathematical description in terms of a construct assignable to color group SU(3) of gauge interactions be-

tween quarks and gluons. This led her to propose that color interactions might have some deep role in living matter. This is in a sharp contrast to the fact that color interactions as establishment knows them are completely invisible above the length scale of 10^{-15} meters. The TGD based prediction that there exists an entire hierarchy of scaled up copies of QCD, in particular QCDs with confinement length scale of order cell size, changes completely the situation.

10.2.2 Honeybees as magneto-receptors of the beehive or magnetic cells as magneto-receptors of bee?

Earth's magnetic field has a crucial status in the model of living systems even at the lowest levels of dark matter hierarchy so that Earth's magnetic field is expected to play a role in the functioning of all cells, also bees and ants. This is indeed the case.

It is known that that bees have two navigation systems. The first system is based on the direction of sun and polarization of solar light but does not work on cloudy days. The second navigation system uses Earth's magnetic field and is used in cloudy days. Bees have in their abdomen magnetite (Fe_3O_4) particles of size about 30 nm and iron storage protein ferritin which correspond 10 to nm sized super-paramagnetic particles [103]. Magnetite particles and ferritin in principle make possible magneto-reception instead of a mere passive compass behavior.

The minimum option is that honeybee itself does not receive any neural information about the magnetic field but acts as a passive magneto-receptor of the bee colony or sub-colony (such as workers flying to the food source) and that the information contained by the receptor grid allows the sub-colony to deduce its position in the varying magnetic field. "BEEG" would mediate this information to the magnetic body of the (sub-)colony and the general mechanism based on Josephson currents does not require nerve pulse patterns to achieve this.

Since foreagers seem to act as individuals able to navigate in the magnetic field of Earth, it would seem that some cells of the honeybee could act as magneto-receptors so that the reaction of the magnetic particles would be coded to a neural signal. It has been proposed that the changes in the shape of the configurations formed by magnetite particles in a varying magnetic field induce changes in the shape of neuron and in this manner can induce neural signal. This mechanism could also induce the voltage perturbations coding the information to the Josephson current giving rise to the sensory part of EEG as a state of coherent ELF photons. Perhaps the genes expressing these neurons are activated only in foragers and ferritin makes possible the magneto-reception in this sense.

10.2.3 Social bacteria and magneto-tactic bacteria

Magneto-tactic behavior of bacteria [104] was discovered for 30 years ago by microbiologist Richard P. Blakemore and means that certain motile, aquatic bacteria orient and migrate along magnetic field lines. This ability could be

purely passive compass mechanism made possible by the magnetite detected in the bacteria.

During last years we have learned that bacteria are not simple creatures having only single goal: to multiply and fill the Earth. Bacteria are able to communicate and act co-operatively [105]. This raises the question whether hyper-genes could appear already at this level and whether bacteria acting as a colony they individual bacteria could act as magneto-receptors of colony allowing it to detect even variations of the magnetic field much like individual cells in the brain of vertebrates or perhaps even in the abdomen of honeybee are believed to serve as magneto-receptors.

10.2.4 Great leaps in evolution as emergence of higher levels of dark matter hierarchy at level of individuals

The vision about large leaps in evolution led to the view that the emergence of EEG corresponds to the emergence of $k_{em} = 4$ level of dark matter hierarchy. On the other hand, the time scale of gene translation corresponds to that associated with the ordinary EEG, which would suggest that $k_{em} = 4$ level is present already at the lowest life forms. The findings about honeybees support the view that levels up to $k_{em} = 6$ at least are present but are associated with the honeybee colony rather than individuals.

Therefore a more precise formulation of the hypothesis about great leaps in evolution would be that great leaps in evolution correspond to the emergence of a new dark matter level at the level of individual organism. If this view is correct then $k_{em} = 4$ level would correspond to a collective level of consciousness in the case of invertebrates down to bacteria, which are indeed found to form societies [105]. This conforms also with the fact that the genome of invertebrates is too small to allow realization of $k_{em} = 4$ flux sheets as genes or even supergenes. The somewhat unexpected conclusion would be that all activities of invertebrates involving gene expression would be controlled by collective levels of consciousness: invertebrates would not be individuals in this sense. Viruses do not possess DNA translation machinery which is consistent with the absence of also collective $k_{em} = 4$ level. One can of course ask whether the queen of honeybee could be an exception to this rule.

This picture provides also an explanation for the universality of the genetic code would be that $k_{em} = 4$ level controls gene expression: $k_{em} = 4$ indeed corresponds to the length scale assignable to the magnetosphere of Earth.

10.3 Dark matter hierarchy, hierarchical structure of nervous system, and hierarchy of emotions

One can ask how the structural and functional hierarchy of CNS and the hierarchy of emotions relates to the dark matter hierarchy. The basic picture wherefrom one can start is following.

1. The emergence of nervous system corresponds to the emergence of $k_{em} = 3$

level of dark matter hierarchy. For instance, worms and insects would correspond to this level.

2. Vertebrates have EEG and thus the most primitive vertebrates (reptiles) should correspond to $k_{em} = 4$. $k_{em} = 7$ is the highest level for which the natural time scale is below the duration of the human life cycle but need not be the highest level present in CNS of the highest mammals.

3. The emergence of new structures need not mean the emergence of new levels of dark matter hierarchy. Rather, the most reasonable criterion for the presence of these levels is the emergence of behaviors involving long term goals and the magnetic bodies of the parts of brain assignable to the control of this kind of behaviors would correspond to higher values of k_{em}. Also the maximum span of memories at given level should be characterized by the value of k_{em} associated with the brain structures involved (hippocampus, mammillary bodies). This picture conforms with the fact that already insects possess neurons, ganglia, and head containing the predecessor of cerebrum but correspond to $k_{em} = 3$ most naturally.

It is useful to list some basic time scales. 5 Hz frequency in EEG defines the characteristic "drum beat" associated with $k_{em} = 4$ level. The counterpart of .2 second time scale would be 6.7 minutes for $k_{em} = 5$, 9.3 days (day=24 hours) $k_{em} = 6$, and 50.7 years for $k_{em} = 7$ for $\lambda \simeq 2^{11}$.

For goal related emotions the maximal time scale assignable to the achievement of the goal might allow to identify the time scale characterizing corresponding level of dark matter hierarchy. The lowest level emotions would be "primitive" emotions not related to any goal and would be assignable to organs consisting of ordinary cells and correspond to $k_{em} \leq 2$ levels of dark matter hierarchy. Also the typical span of memories should correspond to the time scale $T(k_{em})$.

Brain has anatomic division into midbrain, hindbrain, and forebrain [66]. Midbrain and hindbrain (sometimes both are included in brain stem) is possessed by even the most primitive vertebrates and its emergence could hence correspond to the emergence of $k_{em} = 4$ level and EEG. The emergence of $k_{em} > 4$ levels relates naturally to the emergence of long term planning of motor actions in motor areas. The emergence of limbic brain, which defines the most primitive forebrain, could mean the emergence of $k_{em} = 5$ level and goal related emotions. This conforms with the fact that for mammals forebrain and cerebral hemispheres dominate whereas for other vertebrates hindbrain and cerebellum are in the dominant role.

10.3.1 Reptilian brain as $k_{em} = 4$ system

Reptilian brain contains only the structures corresponding to brain stem (midbrain and hind brain, in particular cerebellum) and would thus correspond to $k_{em} = 4$ level of the hierarchy. Cerebellum is not believed to contribute directly to our consciousness and this might be true quite generally for $k_{em} = 4$ level

of dark matter hierarchy (visual awareness might be an exception as will be found).

Simplest emotions correspond to emotions involving no goal. Moods like excitement, feeling good/bad/tired/strong, etc.. could represent examples of such emotions and could be experienced already by reptilians. Of course, the scaled up variants of these emotions could appear at higher levels of hierarchy and would relate to the states of magnetic bodies (degree of the quantum coherence of Bose-Einstein condensates!).

10.3.2 Limbic system

Limbic system is not possessed by reptiles [68]. It is responsible for emotions, control of emotions, and also emotional intelligence. Limbic system corresponds to the brain of the most mammals. The limbic brain includes the amygdala, anterior thalamic nucleus, cingulate gyrus, fornix, hippocampus, hypothalamus, mammillary bodies, medial forebrain bundle, prefrontal lobes, septal nuclei, and other areas and pathways of the brain.

1. The sub-cortical part of the limbic system involves amygdalar and septal divisions. According to [68] amygdalar division promotes feeding, food-search, angry, and defensive behaviors related to obtaining food. Septal division promotes sexual pleasure, genital swelling, grooming, courtship, and maternal behavior. These divisions are emotional mirror images of each other hand could correspond to $k_{em} = 5$ with 6.7 minute "drum beat".

2. The cortical part of the limbic system contains cingulate gyrus which is the newest part of the limbic system and belongs to thalamo-cingulate division which promotes play, vocalization (e.g., the separation cry), and maternal behavior. $k_{em} = 6$ level would correspond to a "drum beat" of 9.3 days.

3. Frontal lobes [69] are often regarded as the organ of volition. The frontal lobes are involved in motor function, problem solving, spontaneity, memory, language, initiation, judgement, impulse control, and social and sexual behavior. Prefrontal lobes representing the extreme front part of frontal lobes belong also to the limbic system and are responsible for motivation and ability to pose long term goals. This ability distinguishes humans from other primates. For these reasons frontal lobes, in particular prefrontal lobes, could involve the highest levels of dark matter hierarchy in the case of humans. $k_{em} = 7$ with a characteristic time scale of 50 years could be assigned naturally to this level.

Cortico-striatal emotions like sadness, hate, fear anger, surprise, embarrassment, happiness, contentment, and joy involve goal structures and failure or success to achieve the goal in essential manner and would involve prefrontal lobes.

$k_{em} = 7$ and even lower levels can also relate to collective levels of consciousness coded by hyper genes. Hence these emotions could also relate to goals not directly related to the fate of biological body. Mirror neurons are crucial prerequisite of social behavior (autistic children seem to lack them), which suggests that hyper genes are involved at least with them.

Social emotions (feeling embarrassed, ashamed, guilty, loved, accepted, ...) could be induced by the collective levels of dark matter hierarchy as punishments or rewards for social behavior very much like neurotransmitters are believed to provide rewards and punishments at neuronal level.

10.3.3 Neocortex and two kinds of intelligences

Neocortex is often assumed to be superior ("neomammalian") part of the brain and makes the majority of brain hemispheres. The species which are considered to be highly intelligent, such as humans and dolphins, tend to have large amounts of neocortex. The amount of neocortex is roughly proportional to the brain size for primates.

Neocortex cannot correspond to $k_{em} = 7$ as a whole. The decomposition of sensory areas to layers is consistent with $k_{em} = 4$ since it is time resolution which matters in the case of sensory representations. Same conclusion applies to sensory association areas. The fine tuning of the motor control performed by cerebellum is of course consistent with $k_{em} = 4$. Intelligence understood in the conventional sense of the word is accurate, works fast, and is computer like. The part of neocortex responsible for ordinary intelligence would be a rapid and accurate processor of sensory and cognitive representations. Hence $k_{em} = 4$ would be naturally characterize sensory areas, secondary and primary motor areas, to hippocampal representation of declarative memories, and all association areas except dorsolateral prefrontal sensory-motor association cortex where short term memories are represented.

Emotional intelligence works slowly and is responsible for visions and holistic views and would thus correspond to higher levels of dark matter hierarchy. Limbic system is involved with emotions, motivation and long term planning and would thus be responsible for emotional intelligence. Indeed, the damage to frontal lobes [69] need not affect ordinary intelligence but affects emotional intelligence.

10.3.4 The levels of dark matter hierarchy associated with short and long term memory

The time spans of memories should correspond to the time scales assignable to the dark matter hierarchy. According to [72], the span of other than visual short term memories is 30-45 seconds. Visual short term memories [73] representing selected features of visual field are reported to have time span of few seconds whereas so called iconic memories representing entire visual field have much shorter time span.

Visual short term memories are marginally consistent with $k_{em} = 4$ level of hierarchy since for the right brain hemisphere $T = 2$ seconds is predicted to correspond to the lowest EEG frequency. Iconic memories could also correspond to $k_{em} = 4$ level and to higher EEG frequencies.

$k_{em} = 5$ level of dark matter hierarchy corresponds to 400 second "drum beat": hence 40 seconds would correspond to 50 Hz EEG frequency by scaling so that the time span of other than visual short term memories is consistent with $k_{em} = 5$ identification. The short term memories representing stimuli to which motor system is going to respond are located in dorsolateral prefrontal sensory-motor association cortex which could thus correspond to $k_{em} = 5$.

$k_{em} = 6$ would correspond to memories whose span would have upper limit of 9 days. Scaling up of short term memory span would give span of about 1 day and this might relate to the sleep-wake-up cycle. Perhaps it is good to remember what I did during the day and that I existed yesterday! This could also relate to the fact that dreams use the memories of previous day as a material. Usually long term memories are defined as memories with a span longer than year so that few days time scale is a hopefully testable prediction. Frontal lobes are central for personality, which must based on some kind of a self narrative. Hence at least $k_{em} = 6$ should be assignable with some regions of frontal lobes.

$k_{em} = 7$ would correspond to the time scale of 50 years assignable to prefrontal cortex [70] forming part of the limbic system. Scaling from the span of short term memories would give 10 year scale. The stimulation of some regions of temporal lobes induces vivid sensory memories. Hence also temporal lobes should contain $k_{em} = 7$ regions crucial for the long term memory recall. The instantaneous communications with geometric past as a mechanism of long term memory recall involve naturally higher levels of dark matter hierarchy.

Hippocampus and mammillary bodies involved with long term memory recall are part of the limbic system. That hippocampal theta rhythm is in the range 4-12 Hz suggests $k_{em} = 4$ for hippocampus itself and that hippocampus just builds kind of bit sequence which during memory recall is communicated from the geometric past to some part of the future brain or magnetic body.

Anterograde amnesia means an inability to restore long term memories. The damage of hippocampus or of mammillary bodies can induce anterograde amnesia. In the usual conceptual framework the explanation would be the inability to store new long memories. In TGD framework this would be inability to construct those cognitive representations which are communicated to the geometric future in long term memory recall. Retrograde amnesia seems to involve almost always anterograde amnesia and means loss of memories for some time span before the injury. A possible explanation is that injury can propagate also to the geometric past of the brain quantum jump by quantum jump.

During ageing memories tend to be lost but the memories of childhood are the most stable ones. A possible interpretation is that at $k_{em} = 7$ level faster rhythms of generalized EEG tend to disappear: kind of scaled up variant for the process of falling into sleep accompanied by silencing of higher EEG bands could be in question.

10.3.5 What about transpersonal levels of consciousness?

$k_{em} > 7$ levels of dark matter hierarchy cannot relate to the biological body. They could relate to higher collective levels of dark matter hierarchy and evolution of social structures. For instance, the "god module" located to temporal lobes could correspond to $k_{em} > 7$ level of dark matter hierarchy. The memories extending over personal life span claimed by meditators could have interpretation in terms of $k_{em} > 7$ transpersonal levels of consciousness.

11 Appendix

In this appendix the generalization of the notion of imbedding space realizing mathematically the hierarchy of Planck constants is discussed and tables for cyclotron frequencies are given.

11.1 Generalization of the notion of imbedding space

Quite generally, the hierarchy of Planck constant is realized by generalizing the notion of imbedding space such that one has a book like structure with various almost-copies of imbedding space glued together like pages of book. Each page of book correspond to a particular level of dark matter hierarchy and darkness means that there are no Feynman diagrams in which particles with different value of Planck constant would appear. The interactions between different levels of hierarchy involve transfer of the particles mediating the interaction between different pages of the book. Physically this means a phase transition changing the value of Planck constant. At classical level the interactions correspond to the leakage of magnetic and electric fluxes and radiation fields between different pages of the book.

The original generalization of imbedding space was too restricted and the belief that the proposed generalization of the imbedding space could explain naturally phenomena like quantum Hall effect involving fractionization of quantum numbers like spin and charge turned out to be wrong. The idea was that a given page of the book like structure would correspond to an orbifold obtained from H by identifying the points of H obtained from each other by the action of group $G_a \times G_b$, where the factors act in M^4 and CP_2 degrees of freedom. As a matter fact, this identification implies just the opposite of fractionization if these quantum numbers are assigned with the symmetries of the imbedding space. For instance, quantization unit for orbital angular momentum becomes n_a where Z_{n_a} is the maximal cyclic subgroup of G_a.

One can however imagine of obtaining fractionization at the level of imbedding space for space-time sheets, which are analogous to multi-sheeted Riemann surfaces (say Riemann surfaces associated with $z^{1/n}$ since the rotation by 2π understood as a homotopy of M^4 lifted to the space-time sheet is a non-closed curve. Continuity requirement indeed allows fractionization of the orbital quantum numbers and color in this kind of situation.

11.1.1 Both covering spaces and factor spaces are possible

The observation above stimulates the question whether it might be possible in some sense to replace H or its factors by their multiple coverings.

1. This is certainly not possible for M^4, CP_2, or H since their fundamental groups are trivial. On the other hand, the fixing of 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 a geodesic sphere of CP_2. $\hat{M}^4 = M^4 \backslash M^2$ and $\hat{CP}_2 = CP_2 \backslash S^2$ 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. H_4 represents a straight cosmic string. Quantum field theory phase corresponds to Jones inclusions with Jones index $\mathcal{M} : \mathcal{N} < 4$. Stringy phase would by previous arguments correspond to $\mathcal{M} : \mathcal{N} = 4$. Also these Jones inclusions are labelled by finite subgroups of $SO(3)$ and thus by Z_n identified as a maximal Abelian subgroup.

   One can argue that cosmic strings are not allowed in QFT phase. This would encourage the replacement $\hat{M}^4 \times \hat{CP}_2$ implying that surfaces in $M^4 \times S^2$ and $M^2 \times CP_2$ are not allowed. In particular, cosmic strings and CP_2 type extremals with M^4 projection in M^2 and thus light-like geodesic without zitterwebegung essential for massivation are forbidden. This brings in mind instability of Higgs=0 phase.

3. The covering spaces in question would correspond to the Cartesian products $\hat{M}^4{}_{n_a} \times \hat{CP}_{2n_b}$ of the covering spaces of $\hat{M}^4$ and $\hat{CP}_2$ by Z_{n_a} and Z_{n_b} with fundamental group is $Z_{n_a} \times Z_{n_b}$. One can also consider extension by replacing M^2 and S^2 with its orbit under G_a (say tedrahedral, octahedral, or icosahedral group). The resulting space will be denoted by $\hat{M}^4 \hat{\times} G_a$ *resp.* $\hat{CP}_2 \hat{\times} G_b$.

4. One expects 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 tedrahedron, octahedron, or icosahedron. This would bring non-commutative homotopy groups into the picture in a natural manner.

5. Also the orbifolds $\hat{M}^4/G_a \times \hat{CP}_2/G_b$ can be allowed as also the spaces $\hat{M}^4/G_a \times (\hat{CP}_2 \hat{\times} G_b)$ and $(\hat{M}^4 \hat{\times} G_a) \times \hat{CP}_2/G_b$. Hence the previous framework would generalize considerably by the allowance of both coset spaces and covering spaces.

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 M^4 factor proportional to $\hbar^2$ must be discontinuous at the singular manifold since only in this manner the idea about different scaling factor of M^4 metric can make sense. This is consistent with the identical vanishing of Chern-Simons action in $M^2 \times S^2$.

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^2_I. The deformation of the entire S^2_I to homologically trivial geodesic sphere S^2_{II} 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^2_I of CP_2 can be deformed to that of S^2_{II} 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) and classical light-like homotopies (cobordisms) are very relevant for the understanding of phase transitions changing Planck constant.

11.1.2 Do factor spaces and coverings correspond to the two kinds of Jones inclusions?

What could be the interpretation of these two kinds of spaces?

1. Jones inclusions appear in two varieties corresponding to $\mathcal{M} : \mathcal{N} < 4$ and $\mathcal{M} : \mathcal{N} = 4$ and one can assign a hierarchy of subgroups of $SU(2)$ with both of them. In particular, their maximal Abelian subgroups Z_n label these inclusions. The interpretation of Z_n as invariance group is natural for $\mathcal{M} : \mathcal{N} < 4$ and it naturally corresponds to the coset spaces. For

$\mathcal{M} : \mathcal{N} = 4$ the interpretation of Z_n has remained open. Obviously the interpretation of Z_n as the homology group defining covering would be natural.

2. $\mathcal{M} : \mathcal{N} = 4$ should correspond to the allowance of cosmic strings and other analogous objects. Does the introduction of the covering spaces bring in cosmic strings in some controlled manner? Formally the subgroup of $SU(2)$ defining the inclusion is $SU(2)$ would mean that states are $SU(2)$ singlets which is something non-physical. For covering spaces one would however obtain the degrees of freedom associated with the discrete fiber and the degrees of freedom in question would not disappear completely and would be characterized by the discrete subgroup of $SU(2)$.

   For anyons the non-trivial homotopy of plane brings in non-trivial connection with a flat curvature and the non-trivial dynamics of topological QFTs. Also now one might expect similar non-trivial contribution to appear in the spinor connection of $\hat{M}^2\hat{\times}G_a$ and $\hat{CP}_2\hat{\times}G_b$. In conformal field theory models non-trivial monodromy would correspond to the presence of punctures in plane.

3. For factor spaces the unit for quantum numbers like orbital angular momentum is multiplied by n_a *resp.* n_b and for coverings it is divided by this number. These two kind of spaces are in a well defined sense obtained by multiplying and dividing the factors of $\hat{H}$ by G_a *resp.* G_b and multiplication and division are expected to relate to Jones inclusions with $\mathcal{M} : \mathcal{N} < 4$ and $\mathcal{M} : \mathcal{N} = 4$, which both are labelled by a subset of discrete subgroups of SU(2).

4. The discrete subgroups of $SU(2)$ with fixed quantization axes possess a well defined multiplication with product defined as the group generated by forming all possible products of group elements as elements of $SU(2)$. This product is commutative and all elements are idempotent and thus analogous to projectors. Trivial group G_1, two-element group G_2 consisting of reflection and identity, the cyclic groups Z_p, p prime, and tedrahedral, octahedral, and icosahedral groups are the generators of this algebra.

   By commutativity one can regard this algebra as an 11-dimensional module having natural numbers as coefficients ("rig"). The trivial group G_1, two-element group G_2¡ generated by reflection, and tedrahedral, octahedral, and icosahedral groups define 5 generating elements for this algebra. The products of groups other than trivial group define 10 units for this algebra so that there are 11 units altogether. The groups Z_p generate a structure analogous to natural numbers acting as analog of coefficients of this structure. Clearly, one has effectively 11-dimensional commutative algebra in 1-1 correspondence with the 11-dimensional "half-lattice" N^{11} (N denotes natural numbers). Leaving away reflections, one obtains N^7. The projector representation suggests a connection with Jones inclusions. An interesting question concerns the possible Jones inclusions

assignable to the subgroups containing infinitely manner elements. Reader has of course already asked whether dimensions 11, 7 and their difference 4 might relate somehow to the mathematical structures of M-theory with 7 compactified dimensions. One could introduce generalized configuration space spinor fields in the configuration space labelled by sectors of H with given quantization axes. By introducing Fourier transform in N^{11} one would formally obtain an infinite-component field in 11-D space.

5. How do the Planck constants associated with factors and coverings relate? One might argue that Planck constant defines a homomorphism respecting the multiplication and division (when possible) by G_i. If so, then Planck constant in units of $\hbar_0$ would be equal to n_a/n_b for $\hat{H}/G_a \times G_b$ option and n_b/n_a for $\hat{H}\hat{\times}(G_a \times G_b)$ with obvious formulas for hybrid cases. This option would put M^4 and CP_2 in a very symmetric role and allow much more flexibility in the identification of symmetries associated with large Planck constant phases.

11.1.3 Phase transitions changing the value of Planck constant

There are two basic kinds of phase transitions changing the value of Planck constant inducing a leakage between sectors of imbedding space. There are three cases to consider corresponding to

1. leakage in M^4 degrees of freedom changing G_a: the critical manifold is $R_+ \times CP_2$;

2. leakage in CP_2 degrees of freedom changing G_b: the critical manifold is $\delta M^4_+ \times S^2_{II}$;

3. leakage in both degrees of freedom changing both G_a and G_b: the critical manifold is $R_+ \times S^2_{II}$. This is the non-generic case.

For transitions of type 2) and 3) X^2 must go through vacuum extremal in the classical picture about transition.

Covering space can also change to a factor space in both degrees of freedom or vice versa and in this case G can remain unchanged as a group although its interpretation changes.

The phase transitions satisfy also strong group theoretical constraints. For the transition $G_1 \to G_2$ either $G_1 \subset G_2$ or $G_2 \subset G_1$ must hold true. For maximal cyclic subgroups Z_n associated with quantization axes this means that n_1 must divide n_2 or vice versa. Hence a nice number theoretic view about transitions emerges.

One can classify the points of critical manifold according to the degree of criticality. Obviously the maximally critical points corresponds to fixed points of G_i that its points $z = 0, \infty$ of the spheres S^2_r and S^2_{II}. In the case of δM^4_+ the points $z = 0$ and ∞ correspond to the light-like rays R_+ in opposite directions. This ray would define the quantization direction of angular momentum. Quantum phase transitions changing the value of M^4 Planck constant could occur

anywhere along this ray (partonic 2-surface would have 1-D projection along this ray). At the level of cosmology this would bring in a preferred direction. Light-cone dip, the counterpart of big bang, is the maximally quantum critical point since it remains invariant under entire group $SO(3,1)$.

Interesting questions relate to the groups generated by finite discrete subgroups of $SO(3)$. As noticed the groups generated as products of groups leaving R_+ invariant and three genuinely 3-D groups are infinite discrete subgroups of SO(3) and could also define Jones inclusions. In this case orbifold is replaced with orbifold containing infinite number of rotated versions of R_+. These phases could be important in elementary particle length scales or in early cosmology.

As already explained, the original too restricted view about generalization of imbedding space led to the idea about p-adic fractal hierarchy of Josephson junctions. Although this vision can criticized as unrealistic I decided to keep the original section discussing this idea in detail.

Fractal hierarchy of Josephson junctions is not new in TGD framework. The development of quantitative models based on this notion has been however plagued by the absence of concrete idea about what these Josephson junctions look like. The dark matter hierarchy based on hierarchy of scaled up values of Planck constant when combined with the p-adic length scale hierarchy might allow to circumvent the problem.

An essential boost for the development of ideas have been the effects of ELF em fields in living matter explainable in terms of quantum cyclotron transitions in Earth's magnetic field. Especially the fact that these effects appear only in narrow temperature and amplitude windows has provided the key hints concerning the model for the hierarchy of Josephson junctions and EEGs. The discussion of these effects is left to a separate section.

11.2 Em cyclotron frequencies of biologically important ions

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

$$f = \frac{A}{20} \times f(Ca^{2+}) \qquad f(Ca^{2+}) \simeq 15\ Hz\ . \tag{30}$$

Here the strength of the magnetic field is assumed to be $B_{end} = .2$ Gauss $= 2\times 10^{-5}$ Tesla. Note that published material there was an erratic identification $B = B_E = .5$ Gauss due to the calculational error.

The following table lists cyclotron frequencies and their lowest multiples for some of the most important ions.

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

Table 11. The first column gives cyclotron frequency in cycles per second for some ions in Earth's magnetic field assumed to have strength $B_{end} = .2 \times 10^{-4}$ Tesla. The remaining columns give spin or nuclear spin and Larmor frequency f_L.

11.3 Cyclotron frequencies of exotic ions and periodic table

Exotic em and Z^0 ions result when some color bonds in atomic nucleus become charged and are simultaneously ordinary ions. By magnetic flux quantization Z^0 magnetic cyclotron frequencies differ from their electromagnetic counterparts for singly charged ions only by charge ratio factors $Q_Z/Q_{Z,0}$. Hence it is convenient to represent electromagnetic cyclotron frequencies instead. The ions in various periods correspond to bands of EEG: it seems however that satellites of the

harmonics of cyclotron frequencies beta and theta bands and that harmonics of frequencies in alpha band provides a more natural explanation for gamma and higher bands. For completeness cyclotron frequencies for all periods are given although the biologically important heavy ions are rather scarce.

11.3.1 Ions in Helium period correspond to beta and gamma bands

The table below lists the relevant data about ions in He period. Cyclotron frequencies are in the range $(15.8 - 75)$ Hz for nuclear exotic ionization which respects statistics. Note that Be and N atoms are exceptional being fermions in ground state. Li ion has rather high cyclotron frequency 42.9 Hz.

Ion	(Z,A,S)	f_1/Hz	Ion	(Z,A,S)	f_1/Hz
He	(2,4, F)	75	C	(6,12,F)	25.0
Li	(3,7, F)	42.9	N	(7,14,B)	21.4
Be	(4,9,B)	33.3	O	(8,16,F)	18.8
B	(5,11,F)	27.3	F	(9,19,F)	15.8

Table 12. Basic data for the ions in Helium period. Cyclotron frequency and nuclear spin for exotic ion with unit electric charge due to the charged color bond in nucleus. F or B tells the statistics of the electronically ionized atom (most atoms are bosons in ground state).

11.3.2 Ions in Neon period correspond to alpha band

For Neon period nuclear exotic ionization the frequencies span the range $8.5 - 15.0$ Hz: only 15 Hz cyclotron frequency of Ne belongs to beta band.

Ion	(Z,A,S)	f_1/Hz	Ion	(Z,A,S)	f_1/Hz
Ne	(10,20,F)	15.0	Si	(14,28,F)	10.7
Na	(11,23,F)	13.0	P	(15,31,F)	9.7
Mg	(12,24,F)	12.5	S	(16,32,F)	9.4
Al	(13,27,F)	11.1	Cl	(17,35,F)	8.5

Table 13. One can arrange the exotic ions in Neon period to one triplet of exotic ions allowing also spin flip qualia and to a quintet assigned with cyclotron qualia. For the meanings of various notations see previous table.

11.3.3 Ions in Argon period correspond to theta band

Singly ionized exotic ions in Argon period have cyclotron frequencies in the range $(3.6\ Hz < f \leq 7.5\ Hz)$.

Ion	(Z,A,S)	f_1/Hz	Ion	(Z,A,S)	f_1/Hz
Ar	(18,40,F)	7.5	Co	(27,59,F)	5.0
K	(19,39,F)	7.5	Ni	(28,58,F)	5.2
Ca	(20,40,F)	7.5	Cu	(29,63,F)	4.8
Sc	(21,45,F)	6.7	Zn	(30,64,F)	4.7
Ti	(22,48,F)	6.3	Ga	(31,69,F)	4.3
V	(23,51,F)	5.9	Ge	(32,74,F)	4.1
Cr	(24,52,F)	5.7	As	(33,75,F)	4.0
Mn	(25,55,F)	5.5	Se	(34,80,F)	3.8
Fe	(26,56,F)	5.4	Br	(35,79,F)	3.8

Table 14. Basic data for singly charged exotic ions with frequencies in Argon period and having cyclotron frequencies in theta band.

11.3.4 Ions in Krypton period correspond to delta band

Krypton period provides an almost identical copy of Argon period. The cyclotron frequencies of Krypton band are in the range $2.3 - 3.5$ Hz.

Ion	(Z,A,S)	f_1/Hz	Ion	(Z,A,S)	f_1/Hz
Kr	(36,84,F)	3.6	Rh	(45,103,F)	2.9
Rb	(37,85,F)	3.5	Pd	(46,108,F)	2.8
Sr	(38,86,F)	3.5	Cd	(48,114,F)	2.6
Y	(39,89,F)	3.4	Ag	(47,107,F)	2.8
Zr	(40,90,F)	3.3	In	(49,115,F)	2.6
Nb	(41,93,F)	3.2	Sn	(50,120,F)	2.5
Mo	(42,98,F)	3.0	Sb	(51,121,F)	2.5
Tc	(43,99,F)	3.0	Te	(52,130,F)	2.3
Ru	(44,102,F)	2.9	I	(53,127,F)	2.4

Table 15. Basic data for singly charged exotic ions having [Kr] as ground state configuration. Tc does not allow stable isotopes but the lifetimes of two long-lived Tc isotopes are 1.5×10^6 years and 2.1×10^5 years.

11.3.5 Basic data for Xenon period

The table below lists ions with [Xe] ground state. Note that all ions in Xe band do not have stable isotopes and it is questionable whether any biologically interesting ions are in this period. Cyclotron frequencies of singly charged exotic ions in Xenon period vary in the range $1.5 - 2.2$ Hz.

Ion	(Z,A,S)	f_1/Hz	Ion	(Z,A,S)	f_1/Hz
Xe	(54,132,F)	2.3	Yb	(70,174,F)	1.7
Cs	(55,133,F)	2.3	Lu	(71,176,B)	1.7
Ba	(56,138,F)	2.2	Hf	(72,178,F)	1.7
La	(57,139,F)	2.2	Ta	(73,181,F)	1.7
Ce	(58,140,F)	2.1	W	(74,184,F)	1.6
Pr	(59,141,F)	2.1	Re	(75,187,F)	1.6
Nd	(60,142,F)	2.1	Os	(76,192,F)	1.6
Pm	(61,147,F)	2.0	Ir	(77,193,F)	1.6
Sm	(62,152,F)	2.3	Pt	(78,195,B)	1.5
Eu	(63,154,B)	1.9	Au	(79,197,F)	1.5
Gd	(64,158,F)	2.0	Hg	(80,202,F)	1.5
Tb	(65,160,F)	1.9	Ti	(81,205,F)	1.5
Dy	(66,164,F)	1.8	Pb	(82,206,F)	1.5
Ho	(67,165,F)	1.8	Bi	(83,209,F)	1.4
Er	(68,166,F)	1.8	Po	(84,209,F)	1.4
Tm	(69,?,?)	?	At	(85,211,F)	1.4

Table 16. Basic data for ions with having [Xe] as ground state configuration.

References

Online books about TGD

[1] M. Pitkänen (2006), *Topological Geometrodynamics: Overview.* http://www.helsinki.fi/∼matpitka/tgdview/tgdview.html.

[2] M. Pitkänen (2006), *Quantum Physics as Infinite-Dimensional Geometry.* http://www.helsinki.fi/∼matpitka/tgdgeom/tgdgeom.html.

[3] M. Pitkänen (2006), *Physics in Many-Sheeted Space-Time.* http://www.helsinki.fi/∼matpitka/tgdclass/tgdclass.html.

[4] M. Pitkänen (2006), *Quantum TGD.* http://www.helsinki.fi/∼matpitka/tgdquant/tgdquant.html.

[5] M. Pitkänen (2006), *TGD as a Generalized Number Theory.* http://www.helsinki.fi/∼matpitka/tgdnumber/tgdnumber.html.

[6] M. Pitkänen (2006), *p-Adic length Scale Hypothesis and Dark Matter Hierarchy.* http://www.helsinki.fi/∼matpitka/paddark/paddark.html.

[7] M. Pitkänen (2006), *TGD and Fringe Physics.* http://www.helsinki.fi/∼matpitka/freenergy/freenergy.html.

Online books about TGD inspired theory of consciousness and quantum biology

[8] M. Pitkänen (2006), *Bio-Systems as Self-Organizing Quantum Systems*. http://www.helsinki.fi/∼matpitka/bioselforg/bioselforg.html.

[9] M. Pitkänen (2006), *Quantum Hardware of Living Matter*. http://www.helsinki.fi/∼matpitka/bioware/bioware.html.

[10] M. Pitkänen (2006), *TGD Inspired Theory of Consciousness*. http://www.helsinki.fi/∼matpitka/tgdconsc/tgdconsc.html.

[11] M. Pitkänen (2006), *Mathematical Aspects of Consciousness Theory*. http://www.helsinki.fi/∼matpitka/genememe/genememe.html.

[12] M. Pitkänen (2006), *TGD and EEG*. http://www.helsinki.fi/∼matpitka/tgdeeg/tgdeeg/tgdeeg.html.

[13] M. Pitkänen (2006), *Bio-Systems as Conscious Holograms*. http://www.helsinki.fi/∼matpitka/hologram/hologram.html.

[14] M. Pitkänen (2006), *Magnetospheric Consciousness*. http://www.helsinki.fi/∼matpitka/magnconsc/magnconsc.html.

[15] M. Pitkänen (2006), *Mathematical Aspects of Consciousness Theory*. http://www.helsinki.fi/∼matpitka/magnconsc/mathconsc.html.

References to the chapters of books

[A1] The chapter *An Overview about the Evolution of Quantum TGD* of [1]. http://www.helsinki.fi/∼matpitka/tgdview/tgdview.html#tgdevo.

[C1] The chapter *Construction of Quantum Theory: Symmetries* of [4]. http://www.helsinki.fi/∼matpitka/tgdquant/tgdquant.html#quthe.

[C2] The chapter *Construction of Quantum Theory: S-matrix* of [4]. http://www.helsinki.fi/∼matpitka/tgdquant/tgdquant.html#towards.

[C6] The chapter *Was von Neumann Right After All* of [4]. http://www.helsinki.fi/∼matpitka/tgdquant/tgdquant.html#vNeumann.

[C7] The chapter *Does TGD Predict the Spectrum of Planck Constants?* of [4]. http://www.helsinki.fi/∼matpitka/tgdquant/tgdquant.html#Planck.

[D6] The chapter *TGD and Astrophysics* of [3]. http://www.helsinki.fi/∼matpitka/tgdclass/tgdclass.html#astro.

[D7] The chapter *Macroscopic Quantum Phenomena and CP_2 Geometry* of [3]. http://www.helsinki.fi/∼matpitka/tgdclass/tgdclass.html#super.

[E9] The chapter *Topological Quantum Computation in TGD Universe* of [5].
http://www.helsinki.fi/∼matpitka/tgdnumber/tgdnumber.html#tqc.

[F2] The chapter *Massless States and Particle Massivation* of [6].
http://www.helsinki.fi/∼matpitka/paddark/paddark.html#mless.

[F3] The chapter *p-Adic Particle Massivation: Hadron Masses* of [6].
http://www.helsinki.fi/∼matpitka/paddark/paddark.html#padmass2.

[F4] The chapter *p-Adic Particle Massivation: Hadron Masses* of [6].
http://www.helsinki.fi/∼matpitka/paddark/paddark.html#padmass3.

[F6] The chapter *Topological Condensation and Evaporation* of [6].
http://www.helsinki.fi/∼matpitka/paddark/paddark.html#padaelem.

[F7] The chapter *The Recent Status of Leptohadron Hypothesis* of [6].
http://www.helsinki.fi/∼matpitka/paddark/paddark.html#leptc.

[F8] The chapter *TGD and Nuclear Physics* of [6].
http://www.helsinki.fi/∼matpitka/paddark/paddark.html#padnucl.

[F9] The chapter *Nuclear String Physics* of [6].
http://www.helsinki.fi/∼matpitka/paddark/paddark.html#nuclstring.

[F10] The chapter *Dark Nuclear Physics and Living Matter* of [6].
http://www.helsinki.fi/∼matpitka/paddark/paddark.html#exonuclear.

[G2] The chapter *The Notion of Free Energy and Many-Sheeted Space-Time Concept* of [7].
http://www.helsinki.fi/∼matpitka/freenergy/freenergy.html#freenergy.

[G3] The chapter *Did Tesla Discover the Mechanism Changing the Arrow of Time?* of [7].
http://www.helsinki.fi/∼matpitka/freenergy/freenergy.html#tesla.

[H1] The chapter *Matter, Mind, Quantum* of [10].
http://www.helsinki.fi/∼matpitka/tgdconsc/tgdconsc.html#conscic.

[H3] The chapter *Self and Binding* of [10].
http://www.helsinki.fi/∼matpitka/tgdconsc/tgdconsc.html#selfbindc.

[H7] The chapter *Conscious Information and Intelligence* of [10].
http://www.helsinki.fi/∼matpitka/tgdconsc/tgdconsc.html#intsysc.

[I1] The chapter *Quantum Theory of Self-Organization* of [8].
http://www.helsinki.fi/∼matpitka/bioselforg/bioselforg.html#selforgac.

[I3] The chapter *Biological Realization of Self Hierarchy* of [8].
http://www.helsinki.fi/∼matpitka/bioselforg/bioselforg.html#bioselfc.

[I4] The chapter *Quantum Control and Coordination in Bio-systems: Part I* of [8].
http://www.helsinki.fi/∼matpitka/bioselforg/bioselforg.html#qcococI.

[I5] The chapter *Quantum Control and Coordination in Bio-Systems: Part II* of [8].
http://www.helsinki.fi/∼matpitka/bioselforg/bioselforg.html#qcococII.

[J1] The chapter *Bio-Systems as Super-Conductors: part I* of [9].
http://www.helsinki.fi/∼matpitka/bioware/bioware.html#superc1.

[J2] The chapter *Bio-Systems as Super-Conductors: part II* of [9].
http://www.helsinki.fi/∼matpitka/bioware/bioware.html#superc2.

[J3] The chapter *Bio-Systems as Super-Conductors: part III* of [9].
http://www.helsinki.fi/∼matpitka/bioware/bioware.html#superc3.

[J4] The chapter *Quantum Antenna Hypothesis* of [9].
http://www.helsinki.fi/∼matpitka/bioware/bioware.html#tubuc.

[J5] The chapter *Wormhole Magnetic Fields* of [9].
http://www.helsinki.fi/∼matpitka/bioware/bioware.html#wormc.

[J6] The chapter *Coherent Dark Matter and Bio-Systems as Macroscopic Quantum Systems* of [9].
http://www.helsinki.fi/∼matpitka/bioware/bioware.html#darkbio.

[K1] The chapter *Time, Spacetime and Consciousness* of [13].
http://www.helsinki.fi/∼matpitka/hologram/hologram.html#time.

[K3] The chapter *General Theory of Qualia* of [13].
http://www.helsinki.fi/∼matpitka/hologram/hologram.html#qualia.

[K4] The chapter *Bio-Systems as Conscious Holograms* of [13].
http://www.helsinki.fi/∼matpitka/hologram/hologram.html#hologram.

[K5] The chapter *Homeopathy in Many-Sheeted Space-Time* of [13].
http://www.helsinki.fi/∼matpitka/hologram/hologram.html#homeoc.

[K6] The chapter *Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin* of [13].
http://www.helsinki.fi/∼matpitka/hologram/hologram.html#metab.

[L1] The chapter *Genes and Memes* of [11].
http://www.helsinki.fi/∼matpitka/genememe/genememe.html#genememec.

[L2] The chapter *Many-Sheeted DNA* of [11].
http://www.helsinki.fi/∼matpitka/genememe/genememe.html#genecodec.

[L4] The chapter *Pre-Biotic Evolution in Many-Sheeted Space-Time* of [11].
http://www.helsinki.fi/∼matpitka/genememe/genememe.html#prebio.

[M1] The chapter *Magnetic Sensory Canvas Hypothesis* of [12].
http://www.helsinki.fi/∼matpitka/tgdeeg/tgdeeg/tgdeeg.html#mec.

[M2] The chapter *Quantum Model for Nerve Pulse* of [12].
http://www.helsinki.fi/∼matpitka/tgdeeg/tgdeeg/tgdeeg.html#pulse.

[M4] The chapter *Quantum Model for EEG: Part I* of [12].
http://www.helsinki.fi/∼matpitka/tgdeeg/tgdeeg/tgdeeg.html#eegI.

[M6] The chapter *Quantum Model for Hearing* of [12].
http://www.helsinki.fi/∼matpitka/tgdeeg/tgdeeg/tgdeeg.html#hearing.

[N1] The chapter *Magnetospheric Sensory Representations* of [14].
http://www.helsinki.fi/∼matpitka/magnconsc/magnconsc.html#srepres.

[N5] The chapter *Semi-trance, Mental Illness, and Altered States of Consciousness* of [14].
http://www.helsinki.fi/∼matpitka/magnconsc/magnconsc.html#semitrancec.

[N6] The chapter *Semitrance, Language, and Development of Civilization* of [14].
http://www.helsinki.fi/∼matpitka/magnconsc/magnconsc.html#langsoc.

[O4] The chapter *DNA as Topological Quantum Computer* of [15].
http://www.helsinki.fi/∼matpitka/mathconsc/mathconsc.html#dnatqc.

Mathematics related references

[16] B. Shipman (1998) *The geometry of momentum mappings on generalized flag manifolds, connections with a dynamical system, quantum mechanics and the dance of honeybee.*
http://math.cornell.edu/ oliver/Shipman.gif.
B. Shipman (1998), *On the geometry of certain isospectral sets in the full Kostant-Toda lattice.*
http://nyjm.albany.edu:8000/PacJ/1997/Shipman.html .
B. Shipman (1998), *A symmetry of order two in the full Kostant-Toda lattice.*
http://www.math.rochester.edu:8080/u/shipman/symmetrypaper/.

General physics related references

[17] K. Abe *et al* (1994), Phys. Rev. Lett. Vol 73, No 1.

[18] *Magnetosphere*,
http://www.oulu.fi/ spaceweb/textbook/magnetosphere.html.

[19] Sentman, D., D. (1985), *Schumann Resonances*, in CRC Handbook of Atmospheric Electrodynamics, (Hans Volland, ed.), CRC Press, Boca Raton.
http://sprite.gi.alaska.edu/schuchar.htm.
Schumann Resonance,
http://www.oulu.fi/ spaceweb/textbook/schumann.html.

[20] L. F. Jaffe (2001), *Calcium Waves*,
http://wave s.mbl.edu/calcium.waves.html.

[21] A. Schienle, R. Stark, R. Kulzer, R. Klpper and D. Vaitl (1996) *Atmospheric electromagnetism: individual differences in brain electrical response to simulated sferics*. International Journal of Psychophysiology, 21, 177.

[22] G. Elert (2005)*Electric Field on Earth*,
http://hypertextbook.com/facts/1998/TreshaEdwards.shtml.

[23] *The Earth's Crust, Lithosphere and Asthenosphere*,
http://www.windows.ucar.edu/tour/link=/earth/interior/earths_crust.html.

[24] L. A. Frank, W. R. Paterson, K. L. Ackerson, S. Kokubun, and T. Yamamoto (1996), *Plasma velocity distributions in the near-Earth plasma sheet: A first look with the Geotail spacecraft*, J. Geophys. Res., 101, pp. 10,627-10,637. http://www-pi.physics.uiowa.edu/www/cpi/cpi-nuggets.html.

[25] G. Baym (1969), *Lectures on Quantum Mechanics*, W. A. Benjamin, Inc..

High Tc superconductivity

[26] M. Rabinowitz (2001), *Phenomenological Theory of Superfluidity and Super-conductivity*,
http://arxiv.org/ftp/cond-mat/papers/0104/0104059.pdf.

[27] S. Sachdev (1999) *Quantum phase transitions (summary)*, Physics World April pp. 33-38.

[28] J. Flouquet and A. Boudin (2002), *Ferromagnetic super-conductors*, Physics Web, http://physicsweb.org/articles/world/15/1/9.

[29] F. Levy, I. Sheikin, B. Grenier, and A. D. Huxley (2005), *Magnetic Field-Induced Super-conductivity in the Ferromagnet URhGe*, Science 26, August, 1343-1346.
See also P. Rogers (2005), *Critical breakthrough*, Physics Web,
http://physicsweb.org/articles/news/9/8/17.

[30] D. Aoki *et al* (2001), *Coexistence of super-conductivity and ferromagnetism in URhGe* (restricted access), Nature 413 613-616.

S. S. Saxena *et al* (2000),*Super-conductivity at the border of itinerant electron ferromagnetism in* UGe_2 (restricted access) Nature 406, 587-592.
C. Pfleiderer *et al* (2001), *Coexistence of super-conductivity and ferromagnetism in d band metal* $ZrZn_2$ (restricted access), Nature 412 58-61.

[31] M. Springford (ed) (1997), *Electron: A Centennary Volume*, Cambridge University Press.

[32] N. D. Mathur *et al* (1998), Nature 394, 39.
See also *Magnetic superglue promotes super-conductivity*, Physics Web, http://physicsweb.org/articles/news/2/7/3.

[33] G. Burns (1993) *High Temperature Super Conductivity*, Academic Press, Inc.

[34] J. Carbotte, E. Schachinger, D. N. Basov (1999), Nature 401, p. 354-356.

[35] D. J. E. Callaway (1992) *Landau, Abrikosov, Hofstadter: Magnetic Flux Penetration in a Lattice Super-conductor*, Ann. of Phys. 224, 210 (1993).

[36] G. Deutcher(1990), article *Short coherence length and granular effects in conventional and high* T_c *super-conductors* in the book *Earlier and Recent Aspects of Super Conductivity* (eds. J. G. Bednorz and K. A. Muller), Springer Verlag.

[37] *Copper*, http://en.wikipedia.org/wiki/Copper.

[38] E. Del Giudice and G. Preparata (1994), *Coherent dynamics in water as a possible explanation of biological membrane formation*, J. of Biol. Phys. 20: 105-116.

[39] I. Morgenstern (1990), article *Spin-Glass behavior of high* T_c *super conductors* in the book *Earlier and Recent Aspects of Super Conductivity* (eds. J. G. Bednorz and K. A. Muller), Springer Verlag.

[40] D. A. Wollman *et al* (1993), *Experimental determination of the superconducting pairing state in YBCO from the phase coherence of YBCO-Pb dc SQUIDs*. Phys. Rev. Lett. B 71, 2134-2137.

[41] J. Orenstein, *Electrons pair themselves*, Nature 401.

[42] J. Orenstein *et al* (1990), in *Electronic properties of high* T_c *super conductors* (ed. H. Kuzmany) 254-259. Springer, Berlin.

[43] J. Rossat-Mignot *et al* (1994), Physica (Amsterdam) 235 C, 59.

[44] H.A. Moock *et al* (1993), Phys. Rev. Lett. 70, 3490.

[45] H. S. Fong *et al* (1995), Phys. Rev. Lett. 75, 316.

[46] E. Demler and S.-C. Zhang (1995), Phys. Rev. Lett. Vol. 75, No 22.

[47] J. Zaanen (2005), *Why high Tc is exciting?*,
http://www.lorentz.leidenuniv.nl/research/jan_hitc.pdf.

[48] M. Buchanan (2001), *Mind the pseudogap*, Nature, vol 408, January 4.
http://www.physique.usherbrooke.ca/taillefer/Projets/Nature-409008.pdf

[49] *High temperature and other unconventional superconductors.*
http://www.fkf.mpg.de/metzner/research/hightc/hightc.html.

[50] V. J. Emery, S. A. Kivelson,, and J. M. Tranquada (1999), *Stripe phases in high-temperature superconductors*, Perspective, Vol. 96, Issue 16, 8814-8817, August 3.
http://www.pnas.org/cgi/reprint/96/16/8814.pdf.

[51] J. Zaanen (2006), *Superconductivity: Quantum Stripe Search*, Nature vol 440, 27 April.
http://www.lorentz.leidenuniv.nl/ jan/nature03/qustripes06.pdf.

[52] Bio-chemistry laboratory U.S. Naval Air Development Center, Pennsylvania (1971), *Evidence from Activation Energies for Super-conductive Tunneling in Biological Systems at Physiological Temperatures*, Physiological Chemistry and Physics 3, pp. 403-410.

[53] E. Del Giudice, S. Doglia, M. Milani, C. W. Smith, G. Vitiello (1989), *Magnetic Flux Quantization and Josephson Behavior in Living Systems*, Physica Scripta,Vol. 40, pp. 786-791.

Brain science, consciousness

[54] T. H. Bullock *et al* (1995), *Temporal fluctuations in coherence of brain waves.*
http://cogprints.soton.ac.uk/documents/disk0/00/00/01/11/cog00000111-00/ Temp_fluc_coherence.htm .

[55] T. Deboer (1998), *Brain temperature dependent changes in the electroenceplahogram power spectrum of humans and animals*, J. Sleep Res. 7(4): 254-62.

[56] D. Cohen (1972), *Magnetoencephalography: detection of Brain's Electrical Activity with a Super-conducting Magnetometer*, Science, 175, 664-666.

[57] *Electroencephalography*,
http://en.wikipedia.org/wiki/Electroencephalography.

[58] *An Intro to Sleep: What is Sleep?*
http://www.talkaboutsleep.com/sleep-disorders/archives/intro.htm.

[59] *Sleep spindle*,
http://en.wikipedia.org/wiki/Sleep_spindle.

[60] Jaan Suurkyla, *Transcendental Meditation - neuro-physiological transformation by way of a unique fourth state of consciousness*, http://home.swipnet.se/tmdoctors/eng/tmunique.htm.

[61] *EEG correlates of consciousness during sleep: a pilot study*, http://www.spiritwatch.ca/LL%209(2)%20web/mason%20article.htm.

[62] C. C. Hiew (1995), *Hemi-Synch into creativity.* Hemi-Synch Journal, XII (1), pp. 3-5.

[63] R. Hink *et al* (1980), *Binaural interaction of a beating frequency following response*, Audiology, 19, pp. 36-43.

[64] D. McMillin (1991), "The Pineal", in *The Treatment of Schizophrenia*, A.R.E. Press, Virginia.
http://www.meridianinstitute.com/mh/pineal.html .

[65] L. Feng *et al*(2000), *The Mammalian Pineal Gland May Be The Third Eye.* http://clearwisdom.net/eng/2000/May/18/EM051800_2.htm.

[66] *Brain*, http://en.wikipedia.org/wiki/Brain.

[67] *Brain stem*, http://en.wikipedia.org/wiki/Brain_stem.

[68] *Limbic system*, http://en.wikipedia.org/wiki/Limbic_system.

[69] *Frontal lobes*, http://en.wikipedia.org/wiki/Frontal_lobes.

[70] *Prefrontal cortex*, http://en.wikipedia.org/wiki/Prefrontal_cortex.

[71] *Temporal lobes*, http://en.wikipedia.org/wiki/Temporal_lobes.

[72] *Short term memory*, http://en.wikipedia.org/wiki/Short_term_memory.

[73] *, Visual short term memory* http://en.wikipedia.org/wiki/Visual_short-term_memory.

[74] P. L. Nunez (2000), *Toward a Quantitative Description of Large Scale Neocortical Dynamic Function and EEG*, Behavioral and Brain Sciences, 23, (3): XX.
http://www.bbsonline.org/documents/a/00/00/05/08/.

[75] National Institute of Mental Health, *Bipolar Disorder*, http://www.nimh.nih.gov/publicat/bipolar.cfm#readNow.

[76] Mark Germine (2000), "Experimental verification of Stapp's theory'. http://listserv.arizona.edu/lsv/www/quantum-mind.html.

Effects of em fields on living matter

[77] D. Yarrow (1990), *Spin the tale of the dragon*, review article on biomagnetism,
http://www.ratical.org/ratville/RofD2.html.

[78] W. R. Adey (1992), "Collective properties of cell membranes" in *Interaction Mechanisms of Low-Level Electromagnetic Fields in Living Systems*, (eds. B. Norden and C. Ramel). Oxford University Press, Oxford. pp. 47-77.

[79] R. O. Becker and G. Selden (1990) *The Body Electric: Electromagnetism and the Foundation of Life*. William Morrow & Company, Inc., New York.

[80] S. M. Bawin and W. R. Adey (1975), *Interaction between nervous tissue and weak environmental electric fields*, Ann. N.Y. Acad. Sci. 247:323-330.

[81] C. F. Blackman, J. A. Elder, C. M. Weil, S. G. Benane (1979), *Induction of calsium-ion efflux from brain tissue by radio-frequency radiation: effects of modulation frequency and field strength*. Radio Sci. 14(6S): 93-98.

[82] Blackman, C. F., Benane, S. G., Kinney, L. S., House, D. E., and Joines, W. T., (1982), *Effects of ELF fields on calcium-ion efflux from brain tissue, in vitro*, Radiat. Res. 92:510-520.

[83] Blackman, C. F., Benane, S. G., Rabinowitz, J. R., House, D. E., and Joines, W. T., (1985), *A role for the magnetic field in the radiation-induced efflux of calcium ions from brain tissue, in vitro*, Bioelectromagnetics 6:327-337.

[84] Blackman, C. F., Kinney, L. S., House, D. E., and Joines, W. T., (1989), *Multiple power density windows and their possible origin*, Bioelectromagnetics 10(2):115-128.

[85] C. F. Blackman (1994), "Effect of Electrical and Magnetic Fields on the Nervous System" in *The Vulnerable Brain and Enviromental Risks, Vol. 3, Toxins in Air and Water* (eds. R. L. Isaacson and K. F. Jensen). Plenum Press, New York, pp. 331-355.

[86] Blackman, C.F., Benane, S.G., and House, D.E. (1991): *The influence of temperature during electric- and magnetic-field induced alteration of calcium-ion release from in vitro brain tissue*. Bioelectromagnetics, 12: 173-182.

[87] J. P. Blanchard and C. F. Blackman (1994), "A model of magnetic field effects on biological system with conforming data from a cell culture preparation" in *On the Nature of Electromagnetic Field Interactions with Biological Systems*, edited by Allan H. Frey. R. G. Landes Company. Medical Intelligence Unit.

[88] J. Hamer (1968), "Effects of low level, low frequency electric fields on human reaction time", Commun. Behav. Biol. 2(5)(Part A): 217-222.

[89] A. R. Liboff (1985), "Cyclotron resonance in membrane transport", in *Interaction between Electromagnetic Fields and Cells* (a. Chiabrera, C. Nicolini, and H.P. Schwan, eds.), NATO ASI Series A97, Plenum Press. New York, pp. 281-296.

[90] N. Cherry (2000), Conference report on effects of ELF fields on brain, http://www.tassie.net.au/emfacts/icnirp.txt .

[91] D. Winter, *Earth's magnetic field regions of weakness correlated to sites of political unrest and war: the paradigm quaking measurements of professor Phil Callahan.* A Commentary by Daniel Winter.
http://www.acacialand.com/Callahan.html.

[92] M. Persinger (1999), "The tectonic strain theory as an explanation for UFO phenomena",
http://www.laurentian.ca/www/neurosci/tectonicedit.htm.
Ibid (1995), "On the possibility of directly accessing every human brain by electromagnetic induction of fundamental algorithms", Percept. Mot. Skills, 80(3 Pt 1), 791-9.
Ibid (1987), *Neuropsychological Bases of God Beliefs*, Praeger Publishers.

[93] M. Persinger (1999), *The tectonic strain theory as an explanation for UFO phenomena* http://www.laurentian.ca/www/neurosci/tectonicedit.htm.

[94] M. Persinger (1995), *On the possibility of directly accessing every human brain by electromagnetic induction of fundamental algorithms*, Percept. Mot. Skills, 80(3 Pt 1), 791-9.

[95] M. Persinger (1987) *Neuropsychological Bases of God Beliefs*, Praeger Publishers.

[96] P. P. Gariaev *et al*(2002), *The spectroscopy of bio-photons in non-local genetic regulation*, Journal of Non-Locality and Remote Mental Interactions, Vol 1, Nr 3.
http://www.emergentmind.org/gariaevI3.htm .

[97] R. O. Becker (1990), *Cross Currents*, Penguin Putnam Inc., New York .

[98] (2005), *Why honeybees never forget a face?* , New Scientists 10 December, Vol 188, No 2529, p.22.

[99] *Positional and Navigational Aides*,
http://www.ortho.lsuhsc.edu/Faculty/Marino/EL/EL3/Positional.html

[100] J. L. Kirschvink (1992), Comment on *Constraints on biological effects of weak extremely-low-frequency electromagnetic fields'*, Phys. Rev. A 43, 1039 (1991).
http://prola.aps.org/abstract/PRA/v46/i4/p2178_1.

[101] J. P. Dobson *et al* (1993), *Evocation of epileptiform activity by weak DC magnetic fields*. American Geophysical Union Meeting, Baltimore, Maryland. EOS, v. 74, no. 16.
See also *Weak-Field Magnetic Stimulation of EEG-Recorded Brainwave Activity*,
http://www.keele.ac.uk/research/istm/EEG.html.

[102] K. S. Kruszelnicki, *Magnetic Bees*,
http://www.abc.net.au/science/k2/trek/4wd/Over57.htm.

[103] M. Desoil *et al* (2005), *Definitive identification of magnetite nanoparticles in the abdomen of the honeybee Apis mellifera*. Journal of Physics: Conference Series 17, 45-49.
http://ej.iop.org/links/q70/2pNVzYq3setVI3vrKSt,Eg/jpconf5_17_007.pdf.
See also
Social Insects and the Earth's Magnetic Field: Magnetite in Bees and Ants. http://www.honeybadger.co.za/ntba1_3.htm.

[104] S. Clement (1996), *Magnetic Microbes*,
http://commtechlab.msu.edu/sites/dlc-me/curious/caOc96SC.html.

[105] S. Silberman (2003), *The Bacteria Whisperer*, Wired Magazine, Issue 11.04, April 2003
http://www.wired.com/wired/archive/11.04/quorum.html.

[106] *Physicists challenge notion of electric nerve impulses; say sound more likely*. http://www.scienceblog.com/cms/physicists-challenge-notion-of-electric-nerve-impulses-say-sound-more-likely-12738.html.

[107] *Soliton model*, http://en.wikipedia.org/wiki/Soliton_model.

[108] T. Heimburg and A. D. Jackson (2005), *On soliton propagation in biomembranes and nerves*, PNAS vol. 102, no. 28, p.9790-9795.

[109] T. Heimburg and A. D. Jackson (2005), *On the action potential as a propagating density pulse and the role of anesthetics*, arXiv : physics/0610117 [physics.bio-ph].

[110] K. Graesboll (2006), *Function of Nerves-Action of Anesthetics*, Gamma 143, An elementary Introduction. http://www.gamma.nbi.dk.

[111] *Saltation*, http://en.wikipedia.org/wiki/Saltation.

[112] *Sine-Gordon equation*, http://en.wikipedia.org/wiki/Sine-Gordon.

Miscellaneous

[113] Edgar Mitchell (1999), "Space Flight as an Anticipatory Computing System". http://www.isso.org/inbox/flight.htm .

[114] S. V. Krischevskii (1996), "Extraordinary Fantastic States/Dreams of the of the Astronauts in Near -Earth Orbit: a New Cosmic Phenomenon". Sozn. Fiz Real 1(4) 66 -69.

[115] *The Golden Mean and Heart Harmonics*, http://www.worldhealing.net/goldenmean.html.

[116] B. Carter (2005) *ORMUS: What it is?: An Overview*, http://www.subtleenergies.com/ormus/tw/overview.htm.