About the New Physics Behind Qualia

M. Pitkänen[1], February 1, 2006

[1] Department of Physical Sciences, High Energy Physics Division,
PL 64, FIN-00014, University of Helsinki, Finland.
matpitka@rock.helsinki.fi, http://www.physics.helsinki.fi/∼matpitka/.
Recent address: Puutarhurinkatu 10,10960, Hanko, Finland.

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Abstract

This chapter was originally about the new physics behind qualia. The model of qualia indeed involves a lot of new physics: many-sheeted space-time; massless extremals; exotic Super Virasoro representations associated with discrete qualia; magnetic and cyclotron phase transitions associated with quantum critical quantum spin glass phases of exotic super conductors at cellular space-time sheets; classical color and electro-weak gauge fields in macroscopic length scales, to name the most important ingredients. Gradually the chapter however expanded so that it touches practically all new physics possibly relevant to TGD inspired quantum biology. Various physical mechanisms are discussed in exploratory spirit rather than restricting the consideration to those ideas which seem to be the final word about quantum biology or qualia just at this moment.

1 Introduction

As the title expresses, this chapter was originally about the new physics behind qualia. The model of qualia indeed involves a lot of new physics: many-sheeted space-time; massless extremals; exotic Super Virasoro representations associated with discrete qualia; magnetic and cyclotron phase transitions associated with quantum critical quantum spin glass phases of exotic super conductors at cellular space-time sheets; classical color and electro-weak gauge fields in macroscopic length scales, to name the most important ingredients. Gradually the chapter however expanded so that it touches practically all new physics possibly relevant to TGD inspired quantum biology. Various physical mechanisms are discussed in exploratory spirit rather than restricting the consideration to those ideas which seem to be the final word about quantum biology or qualia just at this moment.

1.1 Living matter and dark matter

Dark matter is identified as a macroscopic quantum phase with large $\hbar$. Also living matter would involve in in an essential manner matter with a large value of $\hbar$ and hence dark, and form conformally confined (in the sense that the net conformal weight of the state is real) blobs behaving like single units with extremely quantal properties, including free will and intentional action in time scales familiar to us. Dark matter would be responsible for the mysterious vital force.

Any system for which some interaction becomes so strong that perturbation theory does not work, gives rise to this kind of system in a phase transition in which $\hbar$ increases to not lose perturbativity gives rise to this kind of "super-quantal" matter. In this sense emergence corresponds to strong coupling. One must however remember that emergence is actually much more and involves the notion of quantum jump. Dark matter made possible by dynamical $\hbar$ is necessary for macroscopic and macro-temporal quantum coherence and is thus prerequisite for emergence.

Physically large $\hbar$ means a larger unit for quantum numbers and this requires that single particle states form larger particle like units. This kind of collective states with weak mutual interactions are of course very natural in strongly interacting systems. At the level of quantum jumps quantum jumps integrate effectively to single quantum jump and longer moments of consciousness result. Conformal confinement guarantees all this. Entire hierarchy of size scales for conformally confined blobs is predicted corresponding to values of $\hbar$ related to Beraha numbers [C5, E9, C6] but there would be only single value corresponding to very large $\hbar$ for given values of system parameters (gravitational masses, charges,...). The larger the value of $\hbar$ the longer the characteristic time scale of consciousness and of a typical life cycle.

The notion of field body means that dark matter at the magnetic flux tubes would serve as an intentional agent using biological body as a motor instrument and sensory receptor. Dark matter would be the miraculous substance that living systems are fighting for, and perhaps the most important substance in metabolic cycle.

1.2 Macroscopic quantum phases in many-sheeted space-time

The crucial empirical ingredient turned out to be the observations about the effects of oscillating ELF electromagnetic fields on central nervous system, endocrine system and immune system made after sixties [45, 42, 43, 45]. The largest effects are obtained at odd multiples of cyclotron frequencies of various biologically important ions like Ca_{++} in Earth's magnetic field. Also amplitude modulation of RF and MW fields by these frequencies has effects. This leads to a surprising conclusion in violent conflict with standard physics view about world. Magnetically confined states of ions in Earth's magnetic field having minimal size of order cell size and energy scale of order 10^{-14} eV would be in question if ordinary quantum theory would be the final word. Dark matter hierarchy with the spectrum of Planck constants given by $\hbar(k) = \lambda^k \hbar_0$, $\lambda \simeq 2^{11}$, resolves the paradox [M3]. For $k = 4$ level of the dark matter hierarchy the energies $E(k) = \hbar(k)\omega$ of ELF photons are above thermal threshold for $f \geq 1$ Hz.

The notion of many-sheeted ionic equilibrium brings in in the mechanism with which supracurrents at the magnetic flux tubes control the matter at atomic space-time sheets. The strange anomalies challenging the notions of ionic channels and pumps [46] provide support for the resulting general vision.

1.3 Mind like space-time sheets as massless extremals

Mind like space-time sheets are the geometric correlates of selves. So called massless extremals (MEs) [J4] provide ideal and unique candidates for mind like space-time sheets. MEs give rise to hologram like cognitive representations. The assumption that they serve as Josephson junctions allows to understand the amplitude windows associated with the interaction of ELF em fields with brain tissue. The properties of MEs inspire the hypothesis that they give rise to an infinite hierarchy of electromagnetic life forms living in symbiosis with each other and bio-matter. EEG can be interpreted as associated with ELF MEs which is one important level in this hierarchy responsible for the cultural aspects of consciousness.

Our mental images propagating in neural circuits should correspond to microwave (MW) MEs with wavelengths below .3 meters. The communications between quantum antennae associated with ELF and RF MEs provides an elegant model for the formation and recall of long term memories and realize hologrammic cognitive representations. Self hierarchy has as a particular dynamical correlate the hierarchy of Josephson currents modulated by Josephson currents modulated by... having magnetic transition frequencies as their basic frequencies. Josephson currents flow along join along boundaries bonds connecting space-time sheets belonging at various levels of the hierarchy ('biofeedback').

1.4 Classical color and electro-weak fields in macroscopic length scales

One can say that the basic physics of standard model without symmetry breaking and color magnetic confinement is realized at classical level on cellular space-time sheets. Classical Z^0 fields, W fields and gluon fields unavoidably accompany non-orthogonal electric and magnetic fields. The proper interpretation of this prediction is in terms of a p-adic and dark fractal hierarchies of standard model physics with scaled down mass scales making possible long range weak and color interactions in arbitrarily long length scales.

This prediction forces to modify even the model of nuclei [F8]. Nucleons carry exotic color and form nuclear strings consisting of color bonds with exotic quark q and antiquark $\overline{q}$ at their ends. These exotic quarks correspond to $k = 127$ level of dark matter hierarchy. Also dark variants of ordinary quarks with size of about atom are possible. It is also possible to have $u\overline{d}$ and $\overline{u}d$ type color bonds which carry em and weak charge and this means exotic nuclear ionization. Tetraneutron [68, 69] would represent one particular example of this kind of exotically ionized nucleus [F8].

Exotic nuclear physics would have also implications for the ordinary condensed matter physics and could be involved with the very low compressibility of liquid phase and the anomalous behavior of water [F10].

Exotic ionization is the key element in the quantum model for the control action of the magnetic body on biological body. Exotic ionization induces dark plasma oscillations which in turn generate via classical em fields ordinary ohmic currents at the level of the ordinary matter. Nerve pulse patterns [M2] and Ca^{2+} waves [K6, K5] would represent examples of physiological correlates of this quantum control.

1.5 p-Adic-to-real transitions as transformation of intentions to actions

Hearing and cognition are very closely related: one could even argue that we think using language. The view that p-adic physics is physics of intention and cognition leads to the vision that the transformation of thoughts to actions and sensory inputs to thoughts correspond to real–p-adic phase transitions for space-time sheets. For a long time the question how p-adic space-time sheets relate to the real ones lacked a precise answer, and therefore also the question what the transformation of p-adic space-time sheet to real ones really means. The advances in the understanding the precise relationship between p-adic and real space-time sheets discussed in [E1] led however to a definite progress in this respect [H8].

The transformation of p-adic space-time sheets to real ones must respect the conservation of quantum numbers: this requires that the real system either receives or sends energy when the p-adic-to-real transitions realizing the intention occurs. If p-adic ME is transformed to a negative energy ME in the process, real system must make a transition to a higher energy state. This kind of transitions cannot occur spontaneously so that the outcome is a precisely targeted realization of intention. The additional bonus is that buy now-let others pay mechanism makes possible extreme flexibility. There are reasons to expect that the energies involves cannot be too high however.

The model of intentional action as a quantum transition for which the probabilities for various intention-action pairs should in principle be deducible from S-matrix is discussed in [E1] using the vision about physics as a generalized number theory as a guide line. This model leads to fresh insights about the construction of the ordinary S-matrix and essentially the same kind of general expressions for S-matrix elements result as in the case of ordinary scattering.

This picture provides conceptual tools making it possible to discuss the questions what the notion of p-adic cognitive neutrino pair could mean and whether it makes sense to speak about the transformation of p-adic cognitive neutrino pairs to a real cognitive neutrino pairs.

1.6 Exotic super-Virasoro representations

A further piece of new physics of qualia are super-canonical and super-conformal algebras associated with the light-like M^4_+ projections of the light-like boundaries MEs. p-Adic considerations suggest that $L_0 = 0$ condition might be replaced by a weaker condition $L_0 \ mod \ p^n = 0$ in the p-adic context. The interpretation would be in terms of continuous scaling invariance broken to discrete scalings by powers of p: the analogy with lattice systems of condensed matter is obvious. The general condition $a^{L_0} \ mod \ p = 1$, a positive integer, stating invariance under scalings is by Fermat's little theorem satisfied $L_0 \ mod \ p = 0$ and would state that these scalings act like translations by multiples of lattice vector in lattice.

$p \simeq 2^k$ would guarantee approximately the conditions for $a = 2$. For Mersenne primes, which are in an exceptional role physically, these conditions are satisfied in excellent approximation. The so called Gaussian Mersennes allow also to satisfy these conditions in somewhat more general sense and, rather remarkably, there are four Gaussian Mersennes in the length scale range between cell membrane thickness and cell size.

The model for how local p-adic physics codes for the p-adic fractality of the real physics and for intentional action as a quantum jump transforming p-adic space-time sheet to a real one leads to a rather detailed view about the p-adic fractals possibly giving rise to exotic Super Virasoro representations [E1, H8].

The degeneracy of states for exotic representations (number of states with same L_0) is enormous for the physically interesting values of p-adic prime p. This means that these states provide huge negentropy resources. Thus exotic super-canonical representations be interpreted as quantum level articulation for the statement that TGD Universe is quantum critical quantum spin glass. Exotic super-canonical representations clearly provide an excellent candidate for an infinite hierarchy of life forms. These life forms would come in two classes.

1. The representatives of the first class labelled by three integers (k, m, n) if one assumes that physically interesting primes correspond to $p \simeq 2^{k^m}$, k prime and m are integers: n is the power appearing in $L_0 \propto p^n$.

2. The representatives of the second class are labelled by the integers k $L_0 \propto 2^k$, such that $2^k - 1$ is Mersenne prime or $(1+i)^k - 1$ is Gaussian Mersenne.

It is tempting to assume that it is these life forms emerge already in elementary particle length scales and become increasingly complex when the p-adic length scale increases. Life could perhaps be regarded as a symbiosis of these life forms with super-conducting magnetic flux tubes and ordinary matter at atomic space-time sheets. These life forms ('mind') interact with each other, super-conducting magnetic flux tubes and ordinary matter via the classical gauge fields associated with MEs. A natural hypothesis is that the quantum phase transitions of the macroscopic quantum phases for the particles of the exotic super-canonical representations formed in classical fields of MEs (mind like space-time sheets) give rise to some (but not all) qualia.

2 Dark matter and living matter

In the sequel general ideas about the role of dark matter in condensed matter physics are described.

2.1 Quantum criticality, hierarchy of dark matters, and dynamical $\hbar$

Quantum criticality is the basic characteristic of TGD Universe and quantum critical superconductors provide an excellent test bed to develop the ideas related to quantum criticality into a more concrete form.

2.1.1 Quantization of Planck constants and the generalization of the notion of imbedding space

The recent geometric interpretation for the quantization of Planck constants is based on Jones inclusions of hyper-finite factors of type II_1 [A9].

1. Different values of Planck constant correspond to imbedding space metrics involving scalings of M^4 *resp.* CP_2 parts of the metric deduced from the requirement that distances scale as $\hbar(M^4)$ *resp.* $\hbar(M^4)$. Denoting the Planck constants by $\hbar(M^4) = n_a\hbar_0$ and $\hbar(CP_2) = n_b\hbar_0$, one has that covariant metric of M^4 is proportional to n_b^2 and covariant metric of CP_2 to n_a^2. In Kähler action only the effective Planck constant $\hbar_{eff}/\hbar_0 = \hbar(M^4)/\hbar(CP_2)$ appears and by quantum classical correspondence same is true for Schödinger equation. Elementary particle mass spectrum is also invariant. Same applies to gravitational constant. The alternative assumption that M^4 Planck constant is proportional to n_b would imply

invariance of Schrödinger equation but would not allow to explain Bohr quantization of planetary orbits and would to certain degree trivialize the theory.

2. M^4 and CP_2 Planck constants do not fully characterize a given sector $M^4_{\pm} \times CP_2$. Rather, the scaling factors of Planck constant given by the integer n characterizing the quantum phase $q = exp(i\pi/n)$ corresponds to the order of the maximal cyclic subgroup for the group $G \subset SU(2)$ characterizing the Jones inclusion $\mathcal{N} \subset \mathcal{M}$ of hyper-finite factors realized as subalgebras of the Clifford algebra of the "world of the classical worlds". This means that subfactor $\mathcal{N}$ gives rise to G-invariant configuration space spinors having interpretation as G-invariant fermionic states.

3. $G_b \subset SU(2) \subset SU(3)$ defines a covering of M^4_+ by CP_2 points and $G_a \subset SU(2) \subset SL(2,C)$ covering of CP_2 by M^4_+ points with fixed points defining orbifold singularities. Different sectors are glued together along CP_2 if G_b is same for them and along M^4_+ if G_a is same for them. The degrees of freedom lost by G-invariance in fermionic degrees of freedom are gained back since the discrete degrees of freedom provided by covering allow many-particle states formed from single particle states realized in G group algebra. Among other things these many-particle states make possible the notion of N-atom.

4. Phases with different values of scalings of M^4 and CP_2 Planck constants behave like dark matter with respect to each other in the sense that they do not have direct interactions except at criticality corresponding to a leakage between different sectors of imbedding space glued together along M^4 or CP_2 factors. In large $\hbar(M^4)$ phases various quantum time and length scales are scaled up which means macroscopic and macro-temporal quantum coherence. In particular, quantum energies associated with classical frequencies are scaled up by a factor n_a/n_b which is of special relevance for cyclotron energies and phonon energies (superconductivity). For large $\hbar(CP_2)$ the value of $\hbar_{eff}$ is small: this leads to interesting physics: in particular the binding energy scale of hydrogen atom increases by the factor n_b/n_a^2.

2.1.2 A further generalization of the notion of imbedding space

The original idea was that the proposed modification of the imbedding space could explain naturally phenomena like quantum Hall effect involving fractionization of quantum numbers like spin and charge. This does not however seem to be the case. $G_a \times G_b$ implies just the opposite 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.

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 $\hat{M}^4 \times C\hat{P}_2$ 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 $\hat{M}^4{}_{n_a} \times C\hat{P}_{2n_b}$ of the covering spaces of $\hat{M}^4$ and $C\hat{P}_2$ 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.* $C\hat{P}_2 \hat{\times} G_b$.

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 $\hat{M}^4/G_a \times C\hat{P}_2/G_b$ can be allowed as also the spaces $\hat{M}^4/G_a \times (C\hat{P}_2 \hat{\times} G_b)$ and $(\hat{M}^4 \hat{\times} G_a) \times C\hat{P}_2/G_b$. 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.

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: why should 11-D discrete momentum lattice correspond to the lattice of subgroups of SU(2)? 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. Both M^4 and CP_2 would give this kind of factor and together with space-time dimension this would give $D = 26$.

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.

3. Fractional Quantum Hall effect

The generalization of the imbedding space allows to understand fractional quantum Hall effect [35]. The formula for the quantized Hall conductance is given by

$$\begin{aligned} \sigma &= \nu \times \frac{e^2}{h} \ , \\ \nu &= \frac{n}{m} \ . \end{aligned} \tag{1}$$

Series of fractions in $\nu = 1/3, 2/5, 3/7, 4/9, 5/11, 6/13, 7/15...$, $2/3, 3/5, 4/7, 5/9, 6/11, 7/13...$, $5/3, 8/5, 11/7, 14/9...4/$ $1/5, 2/9, 3/13...$, $2/7, 3/11...$, $1/7....$ with odd denominator have been observed as are also $\nu = 1/2$ and $\nu = 5/2$ states with even denominator [35].

The model of Laughlin [33, 34] cannot explain all aspects of FQHE. The best existing model proposed originally by Jain is based on composite fermions resulting as bound states of electron and even number of magnetic flux quanta [36]. Electrons remain integer charged but due to the effective magnetic field electrons appear to have fractional charges. Composite fermion picture predicts all the observed fractions and also their relative intensities and the order in which they appear as the quality of sample improves.

In [E9] I have proposed a possible TGD based model of FQHE not involving hierarchy of Planck constants. The generalization of the notion of imbedding space suggests also the possibility to interpret these states in terms of fractionized charge and electron number.

1. The easiest manner to understand the observed fractions is by assuming that both M^4 and CP_2 correspond to covering spaces so that both spin and electric charge and fermion number are quantized. With this assumption the expression for the Planck constant becomes $\hbar/\hbar_0 = n_b/n_a$ and charge and spin units are equal to $1/n_b$ and $1/n_a$ respectively. This gives $\nu = nn_a/n_b^2$. The values $m = 2, 3, 5, 7, ..$ are observed. Planck constant can have arbitrarily

large values. There are general arguments stating that also spin is fractionized in FQHE and for $n_a = kn_b$ required by the observed values of ν charge fractionization occurs in units of k/n_b and forces also spin fractionization. For factor space option in M^4 degrees of freedom one would have $\nu = n/n_a n_b^2$.

2. The appearance of $n_b = 2$ would suggest that also Z_2 appears as the homotopy group of the covering space: filling fraction 1/2 corresponds in the composite fermion model and also experimentally to the limit of zero magnetic field [36]. Also $\nu = 5/2$ has been observed [37].

3. A possible problematic aspect of the TGD based model is the experimental absence of even values of n_b except $n_b = 2$. A possible explanation is that by some symmetry condition possibly related to fermionic statistics kn/n_b must reduce to a rational with an odd denominator for $n_b > 2$. In other words, one has $k \propto 2^r$, where 2^r the largest power of 2 divisor of n_b smaller than n_b.

4. Large values of n_b emerge as B increases. This can be understood from flux quantization. One has $eBS = n\hbar = n(n_b/n_a)\hbar_0$. The interpretation is that each of the n_b sheets contributes n/n_a units to the flux. As B increases also the flux increases for a fixed value of n_a and area S. Note that the value of magnetic field in given sheet is not affected so that the build-up of multiple covering seems to keep magnetic field strength below critical value. For $n_a = kn_b$ one obtains $eBS/\hbar_0 = n/k$ so that a fractionization of magnetic flux results and each sheet contributes $1/kn_b$ units to the flux. $\nu = 1/2$ corresponds to $k = 1, n_b = 2$ and to non-vanishing magnetic flux unlike in the case of composite fermion model.

5. The understanding of the thermal stability is not trivial. The original FQHE was observed in 80 mK temperature corresponding roughly to a thermal energy of $T \sim 10^{-5}$ eV. For graphene the effect is observed at room temperature. Cyclotron energy for electron is (from $f_e = 6 \times 10^5$ Hz at $B = .2$ Gauss) of order thermal energy at room temperature in a magnetic field varying in the range 1-10 Tesla. This raises the question why the original FQHE requires so low temperature. The magnetic energy of a flux tube of length L is by flux quantization roughly $e^2B^2S \sim E_c(e)m_eL$ ($\hbar_0 = c = 1$) and exceeds cyclotron roughly by a factor L/L_e, L_e electron Compton length so that thermal stability of magnetic flux quanta is not the explanation. A possible explanation is that since FQHE involves several values of Planck constant, it is quantum critical phenomenon and is characterized by a critical temperature. The differences of the energies associated with the phase with ordinary Planck constant and phases with different Planck constant would characterize the transition temperature.

2.1.3 Preferred values of Planck constants

Number theoretic considerations favor the hypothesis that the integers corresponding to Fermat polygons constructible using only ruler and compass and given as products $n_F = 2^k \prod_s F_s$, where $F_s = 2^{2^s} + 1$ are distinct Fermat primes, are favored. The reason would be that quantum phase $q = exp(i\pi/n)$ is in this case expressible using only iterated square root operation by starting from rationals. The known Fermat primes correspond to $s = 0, 1, 2, 3, 4$ so that the hypothesis is very strong and predicts that p-adic length scales have satellite length scales given as multiples of n_F of fundamental p-adic length scale. $n_F = 2^{11}$ corresponds in TGD framework to a fundamental constant expressible as a combination of Kähler coupling strength, CP_2 radius and Planck length appearing in the expression for the tension of cosmic strings, and the powers of 2^{11} seem to be especially favored as values of n_a in living matter [M3].

2.1.4 How Planck constants are visible in Kähler action?

$\hbar(M^4)$ and $\hbar(CP_2)$ appear in the commutation and anticommutation relations of various superconformal algebras. Only the ratio of M^4 and CP_2 Planck constants appears in Kähler action and is due to the fact that the M^4 and CP_2 metrics of the imbedding space sector with given values of Planck constants are proportional to the corresponding Planck constants [A9]. This implies that Kähler function codes for radiative corrections to the classical action, which makes possible to consider the possibility that higher order radiative corrections to functional integral vanish as one might expect at quantum criticality. For a given p-adic length scale space-time sheets with all allowed values of Planck constants are possible. Hence the spectrum of quantum critical fluctuations could in the ideal case correspond to the spectrum of $\hbar$ coding for the scaled up values of Compton lengths and other quantal lengths and times. If so, large $\hbar$ phases could be crucial for understanding of quantum critical superconductors, in particular high T_c superconductors.

2.1.5 Phase transitions changing the level in dark matter hierarchy

The identification of the precise criterion characterizing dark matter phase is far from obvious. TGD actually suggests an infinite number of phases which are dark relative to each other in some sense and can transform to each other only via a phase transition which might be called de-coherence or its reversal and which should be also characterized precisely.

A possible solution of the problem comes from the general construction recipe for S-matrix. Fundamental vertices correspond to partonic 2-surfaces representing intersections of incoming and outgoing light-like partonic 3-surfaces.

1. If the characterization of the interaction vertices involves all points of partonic 2-surfaces, they must correspond to definite value of Planck constant and more precisely, definite groups G_a and G_b characterizing dark matter hierarchy. Particles of different phases could not appear in the same vertex and a phase transition changing the particles to each other analogous to a de-coherence would be necessary.

2. If transition amplitudes involve only a discrete set of common orbifold points of 2-surface belonging to different sectors then the phase transition between relatively dark matters can be described in terms of S-matrix. It seems that this option is the correct one. In fact, also propagators are essential for the interactions of visible and dark matter and since virtual elementary particles correspond at space-time level CP_2 type extremals with 4-dimensional CP_2 projection, they cannot leak between different sectors of imbedding space and therefore cannot mediate interactions between different levels of the dark matter hierarchy. This would suggest that the direct interactions between dark and ordinary matter are very weak.

   If the matrix elements for real-real partonic transitions involve all or at least a circle of the partonic 2-surface as stringy considerations suggest [C2], then one would have clear distinction between quantum phase transitions and ordinary quantum transitions. Of course, the fact that the points which correspond to zero of Riemann Zeta form only a small subset of points common to real partonic 2-surface and corresponding p-adic 2-surface, implies that the rate for phase transition is in general small. On the other hand, for the non-diagonal S-matrix elements for ordinary transitions would become very small by almost randomness caused by strong fluctuations and the rate for phase transition could begin to dominate.

2.1.6 Transition to large $\hbar$ phase and failure of perturbation theory

A further idea is that the transition to large $\hbar$ phase occurs when perturbation theory based on the expansion in terms of gauge coupling constant ceases to converge: Mother Nature would take care of the problems of theoretician. The transition to large $\hbar$ phase obviously reduces gauge coupling

strength α so that higher orders in perturbation theory are reduced whereas the lowest order "classical" predictions remain unchanged. A possible quantitative formulation of the criterion is that maximal 2-particle gauge interaction strength parameterized as $Q_1Q_2\alpha$ satisfies the condition $Q_1Q_2\alpha \simeq 1$.

A justification for this picture would be that in non-perturbative phase large quantum fluctuations are present (as functional integral formalism suggests). At space-time level this would mean that space-time sheet is near to a non-deterministic vacuum extremal. At parton level this would mean that partonic surface contains large number of CP_2 orbifold points so that S-matrix elements for the phase transition becomes large. At certain critical value of coupling constant strength one expects that the transition amplitude for phase transition becomes very large.

2.2 From naive formulas to conceptualization

I have spent a considerable amount of time on various sidetracks in attempts to understand what the quantization of Planck constant does really mean. As usual, the understanding has emerged by unconscious processing rather than by a direct attack.

2.2.1 Naive approach based on formulas

The whole business started from the naive generalization of various formulas for quantized energies by replacing Planck constant with is scaled value. It seems that this approach does not lead to wrong predictions, and is indeed fully supported by the basic applications of the theory. Mention only the quantization of cyclotron energies crucial for the biological applications, the quantization of hydrogen atom, etc... The necessity for conceptualization emerges when one asks what else the theory predicts besides the simple zoomed up versions of various systems.

2.2.2 The geometric view about the quantization of Planck constant

After the naive approach based on simple substitutions came the attempt to conceptualize by visualizing geometrically what dark atoms could look like, and the description in terms of $N(G_a) \times N(G_b)$-fold covering $H \to H/G_a \times G_b$ emerged.

Especially confusing was the question whether one should assign Planck constant to particles or to their interactions or both. It is now clear that one can assign Planck constant to both the "personal" field bodies assignable to particles and to their interactions ("relative" or interaction field bodies), and that each interaction can correspond to both kinds of field bodies. Planck constant for the relative field bodies depends on the quantum numbers of both particles as it does in the case of gravitation. The Planck constant assignable to the particle's "personal" field body makes possible generalizations like the notion of N-atom.

Each sheet of the "personal" field body corresponds to one particular Compton length characterizing one particular interaction and electromagnetic interaction would define the ordinary Compton length. The original picture was that topological condensation of CP_2 type vacuum extremal occurs at space-time sheet with size of Compton length identified usually with particle. In the new picture this space-time sheet can be identified as electromagnetic field body.

Elementary particles have light-like partonic 3-surfaces as space-time correlates. If these 3-surfaces are fully quantum critical, they belong to the intersection of all spaces $H/G_a \times G_b$ with fixed quantization axes. This space is just the 4-D subspace $M^2 \times S^2 \subset M^4 \times CP_2$, where S^2 is geodesic sphere of CP_2. Partonic 2-surfaces are in general non-critical and one can assign to them a definite value of Planck constant.

There are two geodesic spheres in CP_2. Which one should choose or are both possible?

1. For the homologically non-trivial one corresponding to cosmic strings, the isometry group is $SU(2) \subset SU(3)$. The homologically trivial one S^2 corresponds to vacuum extremals and

has isometry group $SO(3) \subset SU(3)$. The natural question is which one should choose. At quantum criticality the value of Planck constant is undetermined. The vacuum extremal would be a natural choice from the point of view of quantum criticality since in this case the value of Planck constant does not matter at all and one would obtain a direct connection with the vacuum degeneracy.

One can of course ask whether all surfaces $M^2 \times Y^2$, Y^2 Lagrangian sub-manifold of CP_2 defining vacuum sectors of the theory should be allowed. The answer seems to be "No" since in the generic case $SO(3)$ does not act as H-isometries of Y^2. If one allows these sub-manifolds or even sub-manifolds of form $M^4 \times Y^2$ to appear as intersection of fractally scaled up variants, one must replace Cartan algebra as algebra associated with $SO(3)$ subgroup of canonical transformations of CP_2 mapping Y^2 to itself (if this kind of algebra exists).

2. The choice of the homologically non-trivial geodesic sphere as a quantum critical sub-manifold would conform with the previous guess that $\mathcal{M} : \mathcal{N} = 4$ corresponds to cosmic strings. It is however questionable whether the ill-definedness of the Planck constant is consistent with the non-vacuum extremal property of cosmic strings unless one assumes that for partonic 3-surfaces $X^3 \subset M^2 \times S^2$ the effective degrees of freedom reduce to mere topological ones.

2.2.3 Fractionization of quantum numbers and the hierarchy of Planck constants

The original generalization of the notion of imbedding space to a union of the factor spaces $\hat{H}/G_a \times G_b$ discussed in the section "General ideas about dark matter" does not allow charge fractionization whereas the covering spaces $\hat{H}\hat{\times}(G_a \times G_b)$ allow a fractionization in a natural manner. Also hybrid cases are obtained corresponding $(\hat{M}^4\hat{\times}G_a) \times (\hat{CP}_2/G_b)$ and $(\hat{M}^4/G_a) \times (\hat{CP}_2\hat{\times}G_b)$.

The simplest assumption is that Planck constant is a homomorphism from the lattice like structure of groups with product of groups defined to be the group generated by the groups. This does not fix the formula for the Planck constants completely since one can consider replacing the right hand side of the formula for $\hbar$ by its inverse and only physical input can fix the formula completely.

1. $\hat{H}/G_a \times G_b$ *option*

The safest and indeed natural assumption motivated by Jones inclusions is that physical states in sector $H/G_a \times G_b$ are $G_a \times G_b$ invariant meaning a discrete analog of color confinement. This alone excludes fractionization and actually implies just the opposite of it.

1. For states with vanishing fermionic quantum numbers $G_a \times G_b$ invariance means that wave functions live in the base space $H/G_a \times G_b$. For instance, L_z would be a multiple of n_a defining the order of maximal cyclic subgroup of G_a. Analogous conclusion would hold true for color quantum numbers.

2. Just as in the case of ordinary spin fermionic quantum numbers (spin, electro-weak spin) necessarily correspond to the covering group of the isometry group since a state with a half-odd integer spin does not remain invariant under the subgroups of the rotation group. In particular, states with odd fermion number cannot be $G_a \times G_b$ invariant. For even fermion numbers it is possible to have many-particle states for which individual particles transform non-trivially under orbital $G_a \times G_b$ if total $G_a \times G_b$ quantum numbers in spin like degrees of freedom compensate for the orbital quantum numbers (for instance, total spin is multiple of n_a). Hence the group algebra of $G_a \times G_b$ would characterize the states in orbital degrees of freedom as indeed assumed. The earlier picture would be correct apart from the lacking assumption about overall $G_a \times G_b$ invariance.

3. The construction of these states could be carried out just like the construction of ordinary $G_a \times G_b$ invariant states in H so that the mathematical treatment of the situation involves no mystics elements. Since $G_a \times G_b$ is actually assigned with a sector $M^4_\pm \times CP_2$ with fixed quantization axes and preferred point of H, one has center of mass degrees of freedom for the position of tip of $M^4_\pm$ and a preferred point of CP_2. This gives new degrees of freedom and one would have a rich spectrum of N-electrons, N-nucleons, N-atoms, etc.... behaving effectively as elementary particles. For example, one interesting question is whether 2-electrons could be interpreted as Cooper pairs of particular kind This would require either $s_z = 0, l_z = 0$ or $s_z = 1, l_z = mn_a - 1$, $m = 0, 1, 2...$ For instance, for $n_a = 3$ (the minimal value of n_a) one could have $s_z = l, l_z = 2$ with $J_z = 3$. One can also ask whether some high spin nuclei could correspond to N-nuclei.

4. This picture is quite predictive. For instance, in the case of gravitational interactions it would mean that the spin angular momentum of an astrophysical system is a multiple of "personal" gravitational Planck constant GM^2/v_0. The value of v_0 could be deduced from this condition and is expected to be a negative power of 2. In the same manner the relative angular momentum of planet-Sun system would be a multiple of GMm/v_0 using the gravitational Planck constant as a unit. This is a strong prediction but reduces to the Bohr quantization rule for circular orbits.

2. $\hat{H}\hat{\times}(G_a \times G_b)$ option

For this option the units of orbital angular momentum and color hyper charge and isospin are naturally scaled down by the factor n_i. In the case of spin and electro-weak spin this kind of scaling would require a covering group of Abelian Cartan group. Since the first homotopy group of SU(2) vanishes there are no coverings of $SU(2)$ in the ordinary sense of the word but quantum version of $SU(2)$ is an excellent candidate for the counterpart of the covering. Also quantum variants of other Lie groups are highly suggestive on basis of ADE correspondence.

There does not seem to be any absolute need for assuming $G_a \times G_b$ singletness. If so, there would be asymmetry between coverings and factor spaces bringing in mind confined and de-confined phases. Since coverings *resp.* factor spaces are labelled by N^{11}-valued lattice momenta *resp.* their negatives, this asymmetry would be analogous to time reversal asymmetry. Note however that all components of lattice momenta are either positive or negative and that this fits nicely with the interpretation of p-adic integers as naturals and "super-naturals". An intriguing question is whether there might be some connection with M-theory and its 4-D compactifications (dropping reflection group one obtains 7-D lattice).

3. Implications of the new picture

This picture has several important implications.

1. There is a symmetry between CP_2 and M^4 so that for a given value of Planck constant one obtains factor space with divisor group $G_a \times G_b$ and covering space with homotopy group $G_b \times G_a$. For large values of Planck constant the large Z_n symmetry acts in M^4 factor *resp.* CP_2 factor for these two options. Therefore the large Z_n symmetry in M^4 degrees of freedom, which can be challenged in some of the applications, could be replaced with large Z^n symmetry in CP_2 degrees of freedom emerging rather naturally.

2. For a large value of Planck constant it is possible to obtain a relatively small dark matter symmetry group in M^4 factor and also the small genuinely 3-dimensional symmetry groups (tedrahedral, octahedral, icosahedral groups) can act in M^4 factor as symmetries of dark matter. Hence the groups appearing as symmetries of molecular physics (aromatic rings, DNA,...) could be identified as symmetries of dark electron pairs. These symmetries appear

also in longer length scales (snow flakes and even astrophysical structures). In earlier picture one had to assume symmetry breaking at the level of visible matter.

3. The notion of N-atom generalizes. The original model predicted large electronic charges suggesting instability plus large Z_n symmetry in M^4 degrees of freedom (identified as a symmetry of field body). For instance, in the case of DNA double helix this kind of large rotational symmetry is questionable. Same applies to astrophysical systems with a gigantic value of gravitational Planck constant. The change of the roles of M^4 and CP_2 and charge fractionization would resolve these problems. This would provide a support for the idea that the electronic or protonic hot spots of catalyst and substrate correspond to fractional charges summing up to a unit charge. This framework could provide a proper realization for the original vision that symbolic level of dynamics and sex emerge already at the molecular level with sequences of catalyst sites representing "words" and their conjugates (opposite molecular sexes).

2.3 Dark atoms and dark cyclotron states

The development of the notion of dark atom involves many side tracks which make me blush. The first naive guess was that dark atom would be obtained by simply replacing Planck constant with its scaled counterpart in the basic formulas and interpreting the results geometrically. After some obligatory twists and turns it became clear that this assumption is indeed the most plausible one. The main source of confusion has been the lack of precise view about what the hierarchy of Planck constants means at the level of imbedding space at space-time.

2.3.1 The assumptions of the model of dark atom

Let us briefly summarize the basic assumptions of the model.

1. The quantized values of effective Planck constant appearing in Schrödinger equation are in the set $\hbar_{eff}/\hbar_0 \in \{n_a/n_b, n_b/n_a, n_an_b, 1/(n_an_b)$ corresponding to the sectors $\hat{H}/G_a \times G_b$, $\hat{H}\hat{\times}(G_a \times G_b)$, $\hat{M}^4/G_a \times (\hat{CP}_2\hat{\times})G_b$, and $(\hat{M}^4\hat{\times}G_a) \times \hat{CP}_2/G_b$. Note that one can consider the replacement of the right hand side of the formula for Planck constant by its inverse, and at this stage one must just keep mind open for the options.

2. In the case of covering spaces the units of quantum numbers are replaced by $1/n_a$ and $1/n_b$, n_i the order of maximal cyclic subgroup. Both fermion number, spin, color, and electroweak quantum numbers can fractionize. For factor spaces units are inverses of these and in this case states are $G_a \times G_b$ singlets: hence N-atoms with dark electrons in general involve many-electron states with even number of electrons. Simplest situation corresponds to spin singlet electron pair and one cannot exclude the possibility that valence electrons are dark electrons.

3. It is assumed that the quantum critical sub-manifolds $M^2 \times S^2$ correspond to homologically trivial geodesic sphere. Note that although quantum critical parton orbits are vacuum extremals, induced electric and Z^0 fields are non-vanishing in general. This is a very important point since it makes possible electric and magnetic fluxes between different sectors of the generalized imbedding space H. For instance, nucleus and electrons can belong to different sectors of H. A helpful visualization is provided by a book with pages glued together along $M^2 \times S^2$. Both electric and magnetic flux are assumed to be conserved as it flows from a sector to another one: therefore dark electron in the covering experiences the electric charge of nucleus as scaled down by a factor $1/N(G_b)$ giving the number of sectors.

4. In the case of factor spaces 3-surface is invariant under G_i so that one has $N(G_i)$ strict copies of the particle: G_i invariance selects states with $l_z = nn_a$ and forces many electron states in order to satisfy quantization conditions in the case of spin. Here one can consider the possibility that single particle states transform according to irreducible representations of G_i although the entire state is G_i invariant.

5. In the case of covering spaces there is no need to assume that partonic 3-surface consists of $N(G_i)$ identical copies. In this case the states are naturally classified by the representations of $G_a \times G_b$ identifiable as elements of the corresponding group algebra. Apparently one has a modified statistics since $N(G_a) \times N(G_b)$ states correspond to the same state in the ordinary sense of the word. It can happen that the action of G_i in H has some isotropy subgroup. In fact, the action of D_{2n} in M^2 and S^2 reduces to the action of the corresponding cyclic group Z_n so that has $N(G_i) = n_i$.

6. One can consider quite a number of variants for the dark atom. Even nucleus could be dark (either fractionally charged or N-nucleus with charge $N(G_b)$). Second interesting possibility is atom with ordinary nucleus and dark electrons. It is also possible that only valence electrons are dark and correspond to one of the allowed varieties.

2.3.2 Thermal stability

The energy scale of hydrogen atom is proportional to $1/\hbar^2$. Depending on the sector of H and on the values of n_a and n_b the scale of energy can increase or be reduced. Also charge fractionization in case of covering spaces of $\hat{CP}_2$ reduces the energy scale. By the conservation of electric flux this takes place for both proton and electron so that the energy scale receives a factor $1/N(G_b)^2$. For large values of Planck constant the energy scale is reduced and thermal stability poses upper limit on the value of Planck constant if dark matter is assumed to be in thermal equilibrium with ordinary matter.

The following table lists the four possible options.

I	II	III	IV
$\hat{H}\hat{\times}G_a \times G_b$	$\hat{H}/(G_a \times G_b)$	$(\hat{H}/G_a)\hat{\times}G_b$	$(\hat{H}/G_b)\hat{\times}G_a$

One can also consider two options for the formula of Planck constant.

1. For $\hbar/\hbar_0 = n_a/n_b$ in case of option I and $G_b = Z_n$ thermal stability condition boils down to the condition

$$\begin{array}{ll} I: & Z \geq \frac{n_b^3}{n_a} \times x \ , \\ II: & Z \geq \frac{n_a}{n_b} \times x \ , \\ III: & Z \geq n_a n_b^3 \times x \ , \\ IV: & Z \geq \frac{1}{n_a n_b} \times x \ . \end{array} \quad x \equiv \sqrt{\frac{E_{th}}{E_1}} \ . \tag{2}$$

Here E_{th} denotes thermal energy. Here E_{th} denotes thermal energy. Note that option III maximizes Planck constant for given $G_a \times G_b$ and is therefore especially interesting. Option IV minimizes in turn minimizes it.

By replacing the formula for Planck constant with its inverse ($\hbar/\hbar_0 = n_b/n_a$ for option I) one obtains the conditions

$$
\begin{array}{ll}
I: & Z \geq n_b^2 n_a \times x \ , \\
II: & Z \geq \frac{n_b}{n_a^2} \times x \ , \\
III: & Z \geq \frac{n_b}{n_a} \times x \ , \\
IV: & Z \geq n_a n_b \times x \ .
\end{array}
\qquad x \equiv \sqrt{\frac{E_{th}}{E_1}} \ . \tag{3}
$$

Recall that the preferred values of n_a and n_b correspond to the number theoretically simple quantum phases $exp(i2\pi/n_i)$ expressible using only square root function and rational functions applied on rationals. n_i are given as products $2^k \times \prod_i F_i$, where F_i are distinct Fermat primes.

2. The original proposal for the hierarchy of Planck constants coming as $\hbar/\hbar_0 = \lambda = 2^{11k}$ does not allow stable hydrogen atom at room temperature. This is not a problem since this hierarchy is associated with cyclotron energies.

3. For option I with $n_a = 1$ and $n_b \in \{3, 5, 6, 12\}$ one would have $Z \geq z \in \{1, 6, 10, 81\}$. Carbon atom would satisfy the condition fors $(n_b = 5, n_a = 1)$ and $(n_b = 6, n_a = 2)$.

4. For option II with $n_b = 1$ one obtains $Z \geq n_a$ for $E_{th} \sim E_1$. What is intriguing that aromatic carbon 5- and 6-cycles, which are abundant in biology and correspond to factor space option, would satisfy this condition for $E_{th} \sim E_1$. For $n > 6$-cycles the condition would not be satisfied. Could this condition state something non-trivial about pre-biotic evolution at high temperatures?

5. For option III with $n_b = 3$ meaning charge fractionization and n_a-fold cyclic symmetry one obtains $Z \geq n_a \times 1.3$ at room temperature. For $n_b = 3$ 5-cycles with $\hbar/\hbar_0 = 15$ and 6-cycles with $\hbar/\hbar_0 = 18$ would be stable below room temperature but not higher cycles. This estimate is of course very rough since the energy scale E_1 for possibly dark delocalized free electron pairs appearing in n-cycles need not be exactly equal to E_1.

6. If one replaces the right hand side by its inverse in the expression of Planck constant the factor space option would favor the thermal stability for large values of n_a and n-cycles with large n so that this option does not look reasonable.

2.3.3 Is the fractionization of principal quantum number possible?

One can also consider the fractionization $n \to n/n_b$ of the principal quantum number of hydrogen analogous to that occurring for angular momentum. If one assumes that fractionization occurs only for isometry charges this option is excluded. This argument might quite well be enough to exclude this kind of fractionization.

Since s-wave states correspond to orbits which represent radial motion between two extremes, one could consider the possibility of periodic radial orbits which run to maximal radius, back to the maximum radius at the opposite side and close after N_b loops of this kind, where N_b is the order of maximal cyclic subgroup of G_b. This would be direct a counterpart for a rotational orbit which closes only after N_b full 2π rotations.

One can consider the occurrence of this phenomenon also in the case of ordinary imbedding space. At least inn this case the interpretation in terms of a transition to chaos might be appropriate. In case of generalized imbedding space one could speak about transition to chaos by period N_b-folding and suggest fractionization of the radial quantum number to n/N_b. Similar fractionization could makes sense for all orbits which are not precisely circular. This fractionization would increase the energy scale by a factor n_b^2.

In empty space fractional diagonal quantum number would mean that ordinary hydrogen atom wave functions diverge at spatial infinity. This kind of scaling is consistent with finiteness inside dark sector if the copies of sheet fuse together at at 3-surface belonging to the quantum critical manifold $M^2 \times S^2$.

2.3.4 Possible experimental implications

An interesting possibility is the formation of stable hydrogen bonds as a fusion of N-hydrogen atoms with $N - k$ and k electrons to give rise to a full shell of electrons possessing an exceptional stability.

1. In the case of factor space the state would be analogous to full Fermi sea or full atomic or nuclear shells. The large value of electric charge might make the state unstable. The resulting state would be invariant under $G_a \times G_b$.

2. For covering space option the total quantum numbers for the resulting state would be those of electron. The degeneracy of states is $N(G_a) \times N(G_b)$-fold corresponding to the group algebra of $G_a \times G_b$. This would mean that the full shell for states with given energy E_n would have total energy $n_a n_b E_n$.

Consider next the possible experimental implications of N-atom concept.

1. Valence electrons could transform to dark electrons in one of the four possible senses.

   i) For covering space option fractal electrons could result. Fractal electron and its conjugate would combine to form a particle with quantum numbers of electrons but with larger mass. Catalytic sites are one possible candidate for fractal electrons and catalyst activity could be understood as a strong tendency of fractal electron and its conjugate to fuse to form an ordinary electron. The anomalously high mass would be the tell-tale signature of these exotic electrons. The effective mass of electron in condensed matter is known to vary in wide limits and to exceed electron mass even by a factor of order hundred: is this really a mere standard physics effect?

   ii) For factor space option full electron shells would be the most stable states and would have have rather high fermion number but vanishing spin. Spin singlet electron pairs would define stable $G_a \times G_b$ singlets. These states might behave like Cooper pairs.

   iii) If the value of Planck constant is smaller than its standard value, the molecular bonds containing dark electrons could be stable at anomalously high temperatures. Note that the dependence of the bond energy on Planck constant need not be non-perturbative as it is for atoms. For instance, a naive application of the formulas for vibrational and rotational energies assuming that the parameters of Hamiltonian (such as vibrational energy scale) do not depend on Planck constant would suggest that large Planck constant implies thermal stability in this kind of situations.

   iv) Both fermionic a (Na^+, K^+, Cl^-) and bosonic (Ca^{++}, Mg^{++}) ions are very important in biology. Optimist would interpret this as a support for the plasmoids as predecessors of biological life. These ions are formed in some manner and the simplest manner would be transformation of valence electrons to dark electrons and subsequence delocalization.

2. The recently discovered evidence [74] that Sun has a solid surface consisting mostly of calcium-ferrite is inconsistent with the fact that photosphere has temperature 5800 K (iron melts at 1811 K and calcium-aluminium ferrite in the range 1670-1720 K at normal pressure). Metallic bonds responsible for the solid state are due to the interaction of delocalized conduction electrons with metal atoms. If the valence electrons giving rise to conduction

bands have a reduced value of Planck constant, the energy scale of the valence bands would become higher and raise the melting temperature. The reduction of Planck constant seems necessary by the non-perturbative dependence of atomic binding energies on $\hbar$.

3. The claims of Mills [72] about the scaling up of the binding energy of the hydrogen ground state by a square k^2 ($k = 2, 3, 4, 5, 6, 7, 10$) of an integer in plasma state are a challenge for the theory. The simplest explanation is that the Planck constant is reduced by factor $1/k$.

Before I had realized that $\hbar_{eff}$ satisfies the formula $\hbar_{eff}/\hbar_0 = n_a/n_b$, the presence of $k = 2$ state in spectrum was a difficult problem and I ended up with the idea that the quantum variant of Laguerre polynomials associated with quantized radial motion could explain $n = 1/2$ and also other fractional states. Later it will be found that this approach indeed predicts these quantum numbers approximately! This raises the question whether these states might appear as metastable intermediate states for hydrogen atom in the phase having $\hbar_{eff}/\hbar_0 = 1$ and $n_a = n_b > 1$. These states would be unstable against the phase transition leading to $n_b > kn_a$, $k = 2, 3, ...$

Living matter could perhaps be understood in terms of quantum deformations of the ordinary matter, which would be characterized by the quantum phases $q = exp(i2\pi/N)$. Hence quantum groups, which have for long time suspected to have significance in elementary particle physics, might explain the mystery of living matter and predict an entire hierarchy of new forms of matter.

As demonstrated in [N4], the notion of N-atom leads to an elegant model for the lock and key mechanism of bio-catalysis as well as the understanding of the DNA replication based on the spontaneous decay and completion of fermionic $N < N(G)$-particles to $N = N(G)$-particles. Optimal candidates for the N-particles are N-hydrogen atoms associated with bio-molecules appearing as letters in the "pieces of text" labelling the molecules. Lock and key would correspond to conjugate names in the sense that N_1 and N_2 for the letters in the name and its conjugate satisfy $N_1 + N_2 = N = N(G)$: as the molecules combine, a full fermion shell represented is formed.

2.3.5 What about cyclotron states?

Dark cyclotron states have scaled spectrum $E_n = (n_a/n_b)E_n$ and for large values of n_a one can have energies above thermal threshold. The crucial observation is that the flux of ordinary magnetic field cannot divide into $N(G)$ dark fluxes since magnetic fluxes necessarily vanish at orbifold surfaces. Hence dark magnetic field would carry total flux which is $N(G)$ times higher than the flux of ordinary magnetic field of same intensity. Fermionic analogs of Bose-Einstein condensates are possible so that each cyclotron energy $E_n = n\hbar_0\omega$ would be replaced with spectrum extending from $(n_a/n_b)E_n$ to $(n_a/n_b)N(G_b)E_n$ in case of fractionization.

2.4 Dark matter and mind: general ideas

Dark matter is identified as a macroscopic quantum phase with large $\hbar$ for which particles have complex conformal weights.

The sum of the imaginary parts of conformal weights assumed for number theoretical reasons to be expressible as sums of imaginary parts for the zeros of Riemann Zeta would define a new conserved quantum number, "scaling momentum" [C1]. The conjugation of the complex conformal weight would distinguish between quantum states and their phase conjugates. This point is important since phase conjugate photons represent negative energy signals propagating into geometric past, assumed to be distinguishable from positive energy signals propagating into geometric future, play a key role in TGD based biology: this distinction cannot be made in QFT context.

Living matter could be matter with a large value of $\hbar$ and hence dark, and form conformally confined blobs behaving like single units with extremely quantal properties, including free will and intentional action in time scales familiar to us. Dark matter would be responsible for the mysterious vital force.

Any system for which some interaction becomes so strong that perturbation theory does not work, could give rise to this kind of system in a phase transition in which $\hbar$ increases to not lose perturbativity gives rise to this kind of "super-quantal" matter. In this sense emergence would corresponds to strong coupling. The interpretation would be that strong fluctuations at strong coupling give rise to a large number of orbifold points so that the S-matrix elements to a phase with larger Planck constant become large. Dark matter made possible by dynamical $\hbar$ is necessary for macroscopic and macro-temporal quantum coherence and is thus prerequisite for emergence.

Physically large $\hbar$ means a larger unit for quantum numbers and this requires that single particle states form larger particle like units. This kind of collective states with weak mutual interactions are of course very natural in strongly interacting systems. The N sheets of $M^4_\pm$, where N is the order of group G_b involved with the Jones inclusion in question. Each partonic 2-surface appears as N geometrically identical copies which can however carry different fermionic quantum numbers. Hence the N-fold space-time sheet carry up to N G_b invariant partons with identical quantum numbers so that an effective breaking of Fermi statistics becomes possible.

One implication would be the notion of N-atom, which at the level of quantum jumps quantum jumps integrate effectively to single quantum jump and longer moments of consciousness result. Entire hierarchy of size scales for matter blobs is predicted corresponding to values of $\hbar$. The larger the value of $\hbar$ the longer the characteristic time scale of consciousness and of a typical life cycle.

In RHIC color glass condensate resembles incompressible liquid. Liquids might be liquids because they contain some dark matter at magnetic/Z^0 magnetic flux tubes (darkness follows from the large value of $\hbar$). Incompressibility of liquid could correspond to maximal density of flux tubes and to the fact that magnetic fields have no sources. In accordance with the previous ideas already water could be living and conscious system in some primitive sense.

The notion of field body in turn means that dark matter at the magnetic flux tubes would serve as an intentional agent using biological body as a motor instrument and sensory receptor. Dark matter would be the miraculous substance that living systems are fighting for, and perhaps the most important substance in metabolic cycle.

2.4.1 Hierarchy of dark matters and hierarchy of minds

The notion of dark matter is only relative concept in the sense that dark matter is invisible from the point of view of the ordinary matter. One can imagine an entire hierarchy of dark matter structures corresponding to the hierarchy of space-time sheets for which p-adic length scales differ by a factor $1/v_0 \sim 2^{11}$. The BE condensates of N_{cr} ordinary matter particles would serve as dynamical units for "doubly dark matter" invisible to the dark matter. The above discussed criticality criterion can be applied at all levels of the hierarchy to determine the value of the dynamical interaction strength for which BE condensates of BE condensates are formed.

This hierarchy would give rise to a hierarchy of the values of $\hbar_n/\hbar$ coming as powers of v_0^{-n} as well as a hierarchy of wavelengths with same energy coming as powers or v_0^n. For zero point kinetic energies proportional to $\hbar^2$ this hierarchy would come in powers of v_0^{-2n}, for magnetic interaction energies proportional to $\hbar$ the hierarchy would come in powers v_0^{-n} whereas for atomics energy levels the hierarchy would come in powers of v_0^{2n} (assuming that this hierarchy makes sense).

The most interesting new physics would emerge from the interaction between length scales differing by powers of v_0 made possible by the decay of BE condensates of dark photons to ordinary photons having wavelength shorter by a factor $\sim v_0$. This interaction could provide the royal road to the quantitative understanding how living matter manages to build up extremely complex coherent interactions between different length and time scales.

In the time domain dark matter hierarchy could allow to understand how moments of consciousness organize to a hierarchy with respect to the time scales of moment of consciousness coming as 2^{11k} multiples of CP_2 time scale. Even human life span could be seen as single moment

of consciousness at $k = 14^{th}$ level of the dark matter hierarchy whereas single day in human life would correspond to $k = 12$.

2.4.2 Realization of intentional action and hierarchy of dark matters

How long length scales are able to control the dynamics in short length scales so that the extremely complex process extending down to atomic length scales realizing my intention to write this word is possible. This question has remained without a convincing answer in the recent day biology and there strong objections against the idea that this process is planned and initiated at neuronal level.

I have proposed a concrete mechanism for the realization of intentional action in terms of time mirror mechanism involving the emission of negative energy photons and proceeding as a cascade in a reversed direction of geometric time from long to short length scales [K1]. This cascade would induce as a reaction analogous processes proceeding in the normal direction of geometric time as a response and would correspond to the neural correlates of intentional action in very general sense of the word.

The counterparts for the negative energy signals propagating to the geometric past would be phase conjugate (negative energy) laser beams identifiable as Bose-Einstein condensates of dark photons. In the time reflection these beams would transform to positive energy dark matter photons eventually decaying to ordinary photons. The space-time correlate would be MEs decaying into MEs and eventually to CP_2 type extremals representing ordinary photons.

The realization of intentional action as desires of boss expressed to lower level boss would naturally represented the decay of the phase conjugate dark laser beam to lower level laser beams decaying to lower level laser beams decaying to... . This would represent the desire for action whereas the time reflection at some level would represent the realization desire as stepwise decay to lower level laser beams and eventually to ordinary photons. The strong quantitative prediction would be that these levels correspond to a length and time scale hierarchies coming in powers of $1/v_0 \sim 2^{11}$.

2.4.3 Wave-length hierarchy, coherent metabolism, and proton-electron mass ratio

The fact that a given wavelength length corresponds to energies related to each other by a scaling with powers of v_0 provides a mechanism allowing to transfer energy from long to short long scales by a de-coherence occurring either in the standard or reversed direction of geometric time. De-coherence in the reversed direction of time would be associated with mysterious looking processes like self-assembly allowing thus an interpretation as a normal decay process in reversed time direction.

It is perhaps not an accident that the value of $v_0 \simeq 4.6 \times 10^{-4}$ is not too far from the ratio of $m_e/m_p \simeq 5.3 \times 10^{-4}$ giving the ratio of zero point kinetic energies of proton and electron for a given space-time sheet. Proton mass ratio $m_p/m_e = 1836.15267261$ corresponds in good approximation to $n = 2^2 \times 3^3 \times 17 = 1836$. This integer is of form $n = 9 \times n_F$. This co-incidence could in principle make possible a metabolic mechanism in which dark protons and ordinary electrons co-operate in the sense that dark protons generate dark photon BE condensates with wave length λ transforming to ordinary photons with wavelength $v_0\lambda$ absorbed by ordinary electrons.

Some examples are in order to illustrate these ideas.

1. As already found, in the case of dark atoms the scaling of binding energies as $1/\hbar^2$ allows the coupling of ~ 9 cm scale of brain hemisphere with the length scale ~ 50 μm of large neuron. $N_{cr} \leq 137$ ordinary IR photons would be emitted in single burst and interacting with neuron.

2. For a non-relativistic particle in a box of size L the energy scale is given by $E_1 = \hbar^2\pi^2/2mL^2$ so that the visible photons emitted would have energy scaled up by a factor $(\hbar_s/\hbar)^2 \simeq 4\times 10^6$. The collective dropping of N_{cr} dark protons to larger space-time sheet would liberate a laser beam of dark photons with energy equal to the liberated zero point kinetic energy. For instance, for the p-adic length scale $L(k = 159 = 3 \times 53) \simeq .63$ μm this process would generate laser beam of IR dark photons with energy $\sim .5$ eV also generated by the dropping of ordinary protons from $k = 137$ atomic space-time sheet. There would thus be an interaction between dark protons in cell length scale and ordinary protons in atomic length scale. For instance, the dropping of dark protons in cell length scale could induce driving of protons back to the atomic space-time sheet essential for the metabolism [K6]. Similar argument applies to electrons with the scale of the zero point kinetic energy about 1 keV.

3. If the energy spectrum associated with the conformational degrees of freedom of proteins, which corresponds roughly to a frequency scale of 10 GHz remains also invariant in the phase transition to dark protein state, coherent emissions of dark photons with microwave wave lengths would generate ordinary infrared photons. For instance, metabolic energy quanta of $\sim .5$ eV could result from macroscopic Bose-Einstein condensates of 58 GHz dark photons resulting from the oscillations in the conformational degrees of freedom of dark proteins. A second option is that the conformal energies are scaled by $\hbar_s/\hbar$ (ω would remain invariant). In this case these coherent excitations would generate ordinary photons with energy of about 1 keV able to drive electrons back to the atomic $k = 137$ space-time sheet.

4. Since magnetic flux tubes have a profound role in TGD inspired theory of consciousness, it is interesting to look also for the behavior of effective magnetic transition energies in the phase transition to the dark matter phase. This transition increases the scale of the magnetic interaction energy so that anomalously large magnetic spin splitting $\hbar_s eB/m$ in the external magnetic field could serve as a signature of dark atoms. The dark transition energies relate by a factor $\hbar_s/\hbar$ to the ordinary magnetic transition energies.

For instance, in the magnetic field $B_{end} = 2B_E/5 = .2$ Gauss, where $B_E = .5$ Gauss is the nominal value of the Earth's magnetic field, explaining the effects of ELF em fields on vertebrate brain, dark electron cyclotron frequency is 6×10^5 Hz and corresponds to ordinary microwave photon with frequency ~ 1.2 GHz and wavelength $\lambda \simeq 25$ cm. For proton the cyclotron frequency of 300 Hz would correspond to energy of ordinary photon with frequency of 6×10^5 Hz and could induce electronic cyclotron transitions and spin flips in turn generating for instance magneto-static waves.

It is easy to imagine a few step dark matter hierarchy connecting EEG frequencies of dark matter with frequencies of visible light for ordinary photons. This kind of hierarchy would give considerable concreteness for the notion of magnetic body having size scale of Earth.

2.4.4 A connection with bio-photons

The biologically active radiation at UV energies was first discovered by Russian researcher Gurwitz using a very elegant experimental arrangement [54]. Gurwitz christened this radiation mitogenetic radiation since it was especially intense during the division of cell.

A direct proof for the biological activity of mitogenetic radiation consisted of a simple experiment in which either quartz or glass plate was put between two samples. The first sample contained already growing onion roots whereas the second sample contained roots which did not yet grow. In the case of quartz plate no stimulation of growth occurred unlike for glass plate. Since quartz is not transparent to UV light whereas the ordinary glass is, the conclusion was that the stimulation of growth is due to UV light.

The phenomenon was condemned by skeptics as a pseudo science and only the modern detection technologies demonstrated its existence [53], and mitogenetic radiation became also known as bio-photons (the TGD based model for bio-photons is discussed in [K6]). Bio-photons form a relatively featureless continuum at visible wavelengths continuing also to UV energies, and are believed to be generated by DNA or at least to couple with DNA. The emission of bio-photons is most intense from biologically active organisms and the irradiation by UV light induces an emission of mitogenetic radiation by a some kind of amplification mechanism. It has been suggested that bio-photons represent some kind of leakage of a coherent light emitted by living matter.

According to Russian researcher V. M. Injushin [55], mitochondrios emit red light at wavelengths 620 nm and 680 nm corresponding to energies 2 eV and 1.82 eV. According to the same source, the nucleus of cell sends UV light at wavelengths 190, 280 and 330 nm corresponding to the energies 6.5, 4.4 and 3.8 eV. The interpretation as a kind of leakage of coherent light would conform with the identification in terms of BE condensates of dark photons with $\hbar_s/\hbar \simeq 2^{11}$ emitted at wavelengths varying in the range $.3 - 1.25$ mm and decaying to photons with energies visible and UV range. For instance, 1.82 eV radiation corresponds to a dark photon wave length of 1.4 mm for $v_0(eff) = 2^{-11}$. A bio-control of ordinary bio-matter at sub-cellular level performed by dark matter from the millimeter length scale could be in question. This proposal conforms with the fact that 1 mm defines the scale of the blobs of neurons serving as structural units in cortex.

The analysis of Kirlian photographs has shown that the pattern of visible light emitted by various body parts, for instance ear, code information about other body parts [56]. These bio-holograms for which a general model is discussed in [K4] could be realized as dark photon laser beams.

In phantom DNA effect [51] a chamber containing DNA is irradiated with a visible laser light and the DNA generates as a response coherent visible radiation at same wavelength. Strangely enough, the chamber continues to emit weak laser light even after the removal of DNA. This effect could be due to the decay of a dark photon BE condensate remaining in the chamber. Also the findings of Peter Gariaev [50] about the effects of visible laser light on DNA, in particular the stimulated emission of radio waves in kHz-MHz frequency range might also relate to dark photons somehow.

2.4.5 A connection with the scaling law of homeopathy

The value of the parameter $1/v_0 \simeq 2083$ is essentially the ratio of CP_2 radius and Planck length scale (as also the ratio of Compton lengths of electron and proton) and rather near to $2^{11} = 2048$. Interestingly, much larger number $2 \times 10^{11} \simeq 3 \times 2^{36}$ appears in the simplest form for what I have christened the scaling law of homeopathy [K5]. This rule has been proposed on basis of experimental findings [47] but has no convincing theoretical justification. The scaling law of homeopathy states that high frequency em radiation transforms to a low frequency radiation and vice versa preferably with the frequency ratio $f_{high}/f_{low} \simeq 2 \times 10^{11}$.

The proposed hierarchy of dark matter and ensuing hierarchy of dark laser beams decaying into lower level beams might provide a deeper explanation for the scaling law of homeopathy. The factor 2×10^{11} is with 3 per cent accuracy equal to the integer $n_F = 3 \times 2^{36} \simeq 2.06 \times 10^{11}$ characterizing ruler and compass quantum phase. Hence the interpretation in terms of a phase transition leading from a phase with a large value of Planck constant $\hbar = n_F\hbar_0$ to ordinary phase is possible.

In [K5] I have discussed some mechanisms for the transformation of high energy photons to low energy photons consistent with the rule and proposed a generalization of the rule based on p-adic length scale hypothesis. For instance, high energy visible photons of frequency f could induce an excitation of the receiving system having same frequency, propagating with velocity $\beta = v/c \simeq 10^{-11}/2$, and having wave length equal $\lambda_0 = f/v = \lambda/\beta$. This excitation would in turn couple to photons of wavelength λ_0 and frequency $f_0 = \beta f$.

2.5 Dark matter hierarchy, sensory representations, and motor action

Dark matter hierarchy allows to develop a detailed model for how magnetic bodies use biological bodies as sensory receptors and motor instruments [M3] leading among other things to a generalization of the notion of genome.

For ordinary quantum mechanics photons at EEG frequencies correspond to ridiculously small energies. Dark matter hierarchy is accompanied by a hierarchy of EEGs and its generalizations with the scalings of frequencies predicted to come in powers of $\lambda \simeq 2^{11}$ [M3]. For $k_{em} = 4$ the energies of EEG photons are above thermal threshold at room temperature for $f \geq 1$ Hz, and 5 Hz frequency corresponds to 86 meV energy.

The fact that arbitrarily small frequencies can correspond to energies above thermal threshold at higher levels of dark matter hierarchy implies that photons with arbitrarily low frequencies can have sizable physical effects on matter. This conforms with the findings about the effects of ELF em fields on living matter [M3], and these effects allow to develop a rather detailed model for EEG and identify the parts of EEG correlating with communications of sensory data to the magnetic body and with quantum control performed by the magnetic body [M3].

2.5.1 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 $\hbar(k_{em}) = \lambda^{k_{em}}\hbar_0$, $\lambda \simeq 2^{11}$.

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 $k_{em} = 1$ level of dark matter hierarchy. Also the dynamics of ionic Cooper pairs remains unaffected in the topological condensation to magnetic flux quanta obeying $k_{em} > 1$ dynamics.

2. Cyclotron energies scale as as $\lambda^{k_{em}}$ 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 Earth's magnetic field correspond to $k_{em} = 4$ 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.

2.5.2 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 dynamical $\hbar$. 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 $k_{em} = 4$ 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 $k_{em} < 4$ 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.

2.5.3 Charge entanglement as a tool of generalized motor action

The charge entanglement by W MEs is an essentially new element in the model for generalized motor actions by magnetic body. Also the telepathic sharing of mental images could rely on charge entanglement. The notion was originally applied in the model of nerve pulse generation [M2]. Neutral MEs would in turn be related to communications and memory. The reduction of charge entanglement can induce a quantum jump to a state in which local Bose-Einstein condensates become exotically ionized with certain probability depending on the intensity of W field. Bose-Einstein condensates define pixels of generalized motor maps.

Exotic ionization induces dark plasma oscillations in turn generating various physiological responses such as Ca^{++}, Mg^{++} waves, and nerve pulse patterns giving rise to the motor action as an asymptotic self-organization pattern. Plasma oscillation patterns utilize typically dark microwave photons as metabolic energy. Field code is the correspondence between the spatio-temporal pattern of plasma oscillations and generalized motor action and the number theoretical model for genetic code [L3] generalizes to this context.

2.5.4 Overview about quantum control and coordination

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 repre-

sentations 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 iono-lito 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.

Summarizing, 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].

3 MEs and mes

The development of the model for the detailed identification of the sensory qualia and brain led to a general vision about the evolution of consciousness and information processing in brain. In this section various properties of MEs are summarized.

3.1 Massless extremals

Massless extremals (MEs) are an extremely general solution set of field equations associated with Kähler action [B1] and representing various gauge – and gravitational fields [J4]. Being scale invariant, MEs come in all size scales. The geometry has axial symmetry in the sense that CP_2

coordinates are arbitrary functions of two variables constructed from Minkowski coordinates: light-like coordinate $t-z$ and arbitrary function of the coordinates of the plane orthogonal to the z-axis defining the direction of propagation. The polarization of the electromagnetic field depends on the point of the plane but is temporally constant. MEs represent waves propagating with velocity of light in single direction so that there is no dispersion: preservation of the pulse shape makes MEs ideal for classical communications.

Electric and magnetic parts of various gauge fields are orthogonal to each other and to the direction of propagation. Classical gauge field is sum of a free part plus part having as its source light-like vacuum current. The time dependence of the vacuum current is arbitrary, this is only possible by its light-likeness. This makes it possible to code all kinds of physical information to the time dependence of the vacuum current. MEs can have finite spatial size and in this case they are classical counterparts of virtual photons exchanged between charged particles and represent classical communication between material space-time sheets. MEs carry gravitational waves and also classical Z^0 fields propagating with light velocity.

MEs can also carry constant electric field. In this case either vacuum charges or actual charges near the boundaries of ME contain define the sources of this field. This situation can be also achieved if MEs form double-sheeted structures and wormhole contacts serve as effectively sources of the field. TGD allows the possibility that the two sheets have opposite time orientations and therefore also opposite classical energies. More generally, the exchange of two or more MEs between material space-time sheets can be such that no net momentum exchange occurs so that the absolute minimum of Kähler action only in a finite region of space-time and gives rise to new degenerate absolute minimum of Kähler action since ME has vanishing action. This kind of structures are obvious candidates for cognitive structures since classical nondeterminism is localized in a finite space-time volume. The Universe should be full of MEs with all possible sizes since they have vanishing action: addition of ME with finite time duration yields new absolute minimum of Kähler action since Kähler action does not change in this operation. This suggests that MEs should be of crucial importance in TGD Universe.

MEs serve as receiving and sending quantum antennae [J4]. Light-like vacuum current generates coherent light. Also coherent gravitons are generated. MEs serve also as templates for BE condensation of photons and gravitons with momenta parallel to the light-like vacuum current. Linear structures, say DNA and micro-tubules, are natural but not the only candidates for structures accompanied by MEs. Since MEs are massless, they carry maximal possible momentum. This makes exchange of ME ideal mechanism for locomotion. The possibility of negative energy MEs is especially fascinating since it suggests 'buy now, pay later' mechanism of energy production: perhaps living matter uses MEs to generate coherent motions [I4, I5].

3.1.1 Massless extremals as general solutions of field equations

Let $k = (k^0, k^3, 0, 0)$ be a light like vector of M^4 and $u = u(m^1, m^2)$ arbitrary function of the Minkowski coordinates m^1 and m^2 in the plane orthogonal to the direction of the 3-vector $(k^3, 0, 0)$ associated with k. The surfaces defined by the map

$$s^k \quad = \quad f^k(k \cdot m, u) \ , \tag{4}$$

where f^k and u are arbitrary functions define massless extremals. They describe the propagation of massless fields in the direction of k: the fields are periodic with a period $\lambda = 2\pi/k$ so that only k and its integer multiples are possible wave vectors. The polarization associated with various induced gauge fields depends on the position in (m^1, m^2)-plane and is in the direction of the gradient of u. Field equations involve tensor contractions of the energy momentum tensor and gauge current but these are proportional to kk and k respectively and vanish by the light-likeness

of k. Linear superposition holds true only in a restricted sense since both the propagation direction and the polarization direction in each $(m^1, m^2) = const$ plane is fixed.

What is remarkable that these solutions are not solutions of the ordinary Maxwell equations in vacuum: Kähler current density J_K is in general non-vanishing(!) and proportional to the light like four-momentum k. As a consequence, also a light-like electromagnetic current is in general (but not necessarily) present. The interpretation of the em current J as charged elementary particle current is impossible and the correct interpretation as a vacuum current associated with the induced gauge fields. The finite length of the micro-tubule plus the requirement that the total vacuum charge vanishes, implies that the Fourier decompositions of the massless fields contain only integer multiples of the basic four-momentum k. The direct detection of the light-like vacuum current inside a micro-tubule would provide strong support for TGD.

The physical importance of these extremals is suggested by the fact they are in certain sense elementary particle like objects: in fact, the original interpretation was as a model for the exterior space-time of a topologically condensed massless particle. The solution set is also very general involving several arbitrary functions. Although the minimization of the Kähler action favors the formation of Kähler electric fields, massless extremals might well appear as space-time sheets of the effective space-time. These space-time sheets should not contain ordinary charges since their presence implies a transition to the Maxwell phase described in an excellent approximation by the ordinary Maxwell electrodynamics. The fact that vacuum em current and vacuum Einstein tensor do not in general vanish, could mean that massless extremals serve as sources of coherent photons and gravitons.

Massless extremals can also reduce to vacuum extremals of the Kähler action in the case that the CP_2 projection is, in general two-dimensional, Legendre manifold of CP_2. These extremals are however not gravitational vacua.

3.1.2 Generalization of the solution ansatz defining MEs

The solution ansatz for MEs has developed gradually to an increasingly general form and the following formulation is the most general one achieved hitherto. Rather remarkably, it rather closely resembles the solution ansatz for the CP_2 type extremals and has direct interpretation in terms of geometric optics. Equally remarkable is that the latest generalization based on the introduction of the local light-cone coordinates was inspired by quantum holography principle.

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1. Local light-cone coordinates

The solution involves a decomposition of M^4_+ tangent space localizing the decomposition of Minkowski space to an orthogonal direct sum $M^2 \oplus E^2$ defined by light-like wave vector and polarization vector orthogonal to it. This decomposition defines what might be called local light-cone coordinates.

1. Denote by m^i the linear Minkowski coordinates of M^4. Let (S_+, S_-, E_1, E_2) denote local cooordinates of M^4_+ defining a *local* decomposition of the tangent space M^4 of M^4_+ into a direct *orthogonal* sum $M^4 = M^2 \oplus E_2$ of spaces M^2 and E^2. This decomposition has interpretation in terms of the longitudinal and transversal degrees of freedom defined by local light-like four-velocities $v_\pm = \nabla S_\pm$ and polarization vectors $\epsilon_i = \nabla E_i$ assignable to light ray.

2. In accordance with this physical picture, S_+ and S_- define light-like curves and thus satisfy the equation:

$$(\nabla S_\pm)^2 = 0 \quad .$$

The gradients of $S_\pm$ are obviously analogous to local light like velocities $v = (1, \overline{v})$ and $\tilde{v} = (1, -\overline{v})$. These equations are also obtained in geometric optics from Hamilton Jacobi equation by replacing photon's four-velocity with the gradient ∇S: this is consistent with the interpretation of MEs as Bohr orbits of em field.

3. With these assumptions the coordinates $(S_\pm, E_i)$ define local light-cone coordinates with the metric element having the form

$$ds^2 = g_{S_+S_-} dS_+ dS_- + g_{11} dE_1^2 + g_{22} dE_2^2 \quad .$$

Conformal transformations of M_+^4 leave the general form of this decomposition invariant. The task is to find all possible local light-cone coordinates defining one-parameter families 2-surfaces defined by the condition $S_i = constant$, $i = + \; or \; = -$, dual to each other and expanding with light velocity.

2. A conformally invariant family of local light-cone coordinates

The simplest solutions to the equations defining local light-cone coordinates are of form $S_\pm = k \cdot m$ giving as a special case $S_\pm = m^0 \pm m^3$. For more general solutions of from

$$S_\pm = m^0 \pm f(m^1, m^2, m^3) \quad , \quad (\nabla_3 f)^2 = 1 \quad ,$$

where f is an otherwise arbitrary function, this relationship reads as

$$S_+ + S_- = 2m^0 \quad .$$

This condition defines a natural rest frame. One can integrate f from its initial data at some two-dimensional $f = constant$ surface and solution describes curvilinear light rays emanating from this surface and orthogonal to it. The flow velocity field $\overline{v} = \nabla f$ is irrotational so that closed flow lines are not possible in a connected region of space and the condition $\overline{v}^2 = 1$ excludes also closed flow line configuration with singularity at origin such as $v = 1/\rho$ rotational flow around axis.

One can identify E^2 as a local tangent space spanned by polarization vectors and orthogonal to the flow lines of the velocity field $\overline{v} = \nabla f(m^1, m^2, m^3)$. Since the metric tensor of any 3-dimensional space allows always diagonalization in suitable coordinates, one can always find coordinates (E_1, E_2) such that (f, E_1, E_2) form orthogonal coordinates for $m^0 = constant$ hyperplane. Obviously one can select the coordinates E_1 and E_2 in infinitely many manners.

3. Closer inspection of the conditions defining local light-cone coordinates

Whether the conformal transforms of the local light-cone coordinates $\{S_\pm = m^0 \pm f(m^1, m^2, m^3), E_i\}$ define the only possible compositions $M^2 \oplus E^2$ with the required properties, remains an open question. The best that one might hope is that any function S_+ defining a family of light-like curves defines a local decomposition $M^4 = M^2 \oplus E^2$ with required properties.

1. Suppose that S_+ and S_- define light-like vector fields which are not orthogonal (proportional to each other). Suppose that the polarization vector fields $\epsilon_i = \nabla E_i$ tangential to local E^2 satisfy the conditions $\epsilon_i \cdot \nabla S_+ = 0$. One can formally integrate the functions E_i from these condition sonce the initial values of E_i are given at $m^0 = constant$ slice.

2. The solution to the condition $\nabla S_+ \cdot \epsilon_i = 0$ is determined only modulo the replacement

$$\epsilon_i \to \hat{\epsilon}_i = \epsilon_i + k\nabla S_+ \ ,$$

where k is any function. With the choice

$$k = -\frac{\nabla E_i \cdot \nabla S_-}{\nabla S_+ \cdot \nabla S_-}$$

one can satisfy also the condition $\hat{\epsilon}_i \cdot \nabla S_- = 0$.

3. The requirement that also $\hat{\epsilon}_i$ is gradient is satisfied if the integrability condition

$$k = k(S_+)$$

is satisfied: in this case $\hat{\epsilon}_i$ is obtained by a gauge transformation from ϵ_i. The integrability condition can be regarded as an additional, and obviously very strong, condition for S_- once S_+ and E_i are known.

4. The problem boils down to that of finding local momentum and polarization directions defined by the functions S_+, S_- and E_1 and E_2 satisfying the orthogonality and integrability conditions

$$(\nabla S_+)^2 = (\nabla S_-)^2 = 0 \ , \quad \nabla S_+ \cdot \nabla S_- \neq 0 \ ,$$

$$\nabla S_+ \cdot \nabla E_i = 0 \ , \qquad \frac{\nabla E_i \cdot \nabla S_-}{\nabla S_+ \cdot \nabla S_-} = k_i(S_+) \ .$$

The number of intebrability conditions is 3+3 (all derivatives of k_i except the one with respect to S_+ vanish): thus it seems that there are not much hopes of finding a solution unless some discrete symmetry relating S_+ and S_- eliminates the integrability conditions altogether.

A generalization of the spatial reflection $f \to -f$ working for the separable Hamilton Jacobi function $S_\pm = m^0 \pm f$ ansatz could relate S_+ and S_- to each other and trivialize the integrability conditions. The symmetry transformation of M^4_+ must perform the permutation $S_+ \leftrightarrow S_-$, preserve the light-likeness property, map E^2 to E^2, and multiply the inner products between M^2 and E^2 vectors by a mere conformal factor. This encourages the conjecture that all solutions are obtained by conformal transformations from the solutions $S_\pm = m^0 \pm f$.

4. General solution ansatz for MEs for given choice of local light-cone coordinates

Consider now the general solution ansatz assuming that a local wave-vector-polarization decomposition of M^4_+ tangent space has been found.

1. Let $E(S_+, E_1, E_2)$ be an arbitrary function of its arguments: the gradient ∇E defines at each point of E^2 an S_+-dependent (and thus time dependent) polarization direction orthogonal to the direction of local wave vector defined by ∇S_+. Polarization vector depends on E^2 position only.

2. The most general MEs correspond to the solution family of the field equations having the general form

$$s^k = f^k(S_+, E) \ ,$$

where s^k denotes CP_2 coordinates and f^k is an arbitrary function of S_+ and E. The solution represents a wave propagating with light velocity and having definite S_+ dependent polarization in the direction of ∇E. By replacing S_+ with S_- one obtains a dual solution. Field equations are satisfied because energy momentum tensor and Kähler current are light-like so that all tensor contractions involved with the field equations vanish: the orthogonality of M^2 and E^2 is essential for the light-likeness of energy momentum tensor and Kähler current.

3. The simplest solutions of the form $S_\pm = m^0 \pm m^3$, $(E_1, E_2) = (m^1, m^2)$ and correspond to a cylindrical MEs representing waves propagating in the direction of the cylinder axis with light velocity and having polarization which depends on point (E^1, E^2) and S_+ (and thus time). For these solutions four-momentum is light-like: for more general solutions this cannot be the case. Polarization is in general case time dependent so that both linearly and circularly polarized waves are possible. If m^3 varies in a finite range of length L, then 'free' solution represents geometrically a cylinder of length L moving with a light velocity. Of course, ends could be also anchored to the emitting or absorbing space-time surfaces.

4. For the general solution the cylinder is replaced by a three-dimensional family of light like curves and in this case the rectilinear motion of the ends of the cylinder is replaced with a curvilinear motion with light velocity unless the ends are anchored to emitting/absorbing space-time surfaces. The non-rotational character of the velocity flow suggests that the freely moving particle like 3-surface defined by ME cannot remain in a infinite spatial volume. The most general ansatz for MEs should be useful in the intermediate and nearby regions of a radiating object whereas in the far away region radiation solution is excepted to decompose to cylindrical ray like MEs for which the function $f(m^1, m^2, m^2)$ is a linear linear function of m^i.

3.2 About the electro-weak and color fields associated with massless extremals

Space-time sheets carrying em fields carry usually also Z^0 and W fields and it is not possible to speak about em or Z^0 type MEs. It is however possible to speak about neutral and W MEs. The CP_2 projection of ME is 2-dimensional and in a special case it reduces to a geodesic sphere. There are two kinds of geodesic spheres in CP_2.

1. For space-time sheets for which CP_2 projection is $r = \infty$ homologically non-trivial geodesic sphere of CP_2 one has

$$\gamma = (\frac{3}{4} - \frac{sin^2(\theta_W)}{2})Z^0 \simeq \frac{5Z^0}{8} \quad .$$

   The induced W fields vanish in this case and they vanish also for all geodesic sphere obtained by $SU(3)$ rotation.

2. For homologically trivial geodesic sphere a standard representative is obtained by using for the phase angles of standard complex CP_2 coordinates constant values. In this case induced em, Z^0, and Kähler fields vanish but induced W fields are non-vanishing. This holds also for surfaces obtained by color rotation. Hence one can say that for non-vacuum extremals with 2-D CP_2 projection color rotations and weak symmetries commute.

The MEs corresponding to these two geodesic spheres could be called neutral and W MEs and they carry color fields for which the color group $SU(3)$ reduces to some of its $U(1)$ subgroups. Quite generally, the holonomy algebra of color group is Abelian since the induced color field is of the

form $g^A_{\alpha\beta} \propto H^A J_{\alpha\beta}$, where H^A denotes color Hamiltonian. Neutral MEs are excellent candidates for mediating EEG type communications from the biological body to the magnetic body whereas charge entanglement induced by W MEs would be ideal for the realization of motor actions of the magnetic body.

MEs are excellent candidates for the space-time correlates of laser beams. Dark matter hierarchy implies that also MEs can be classified by the level of the dark matter hierarchy involved. A very general argument leads to the conclusion that dark space-time sheets, in particular MEs, at the k^{th} level of the dark matter hierarchy correspond to space-time sheets defining λ^k-fold coverings of M^4 (recall that one has $\hbar(k) = \lambda^k \hbar_0$ and $\lambda \simeq 2^{11}$) [C6, M3]. $k = 0$ MEs would correspond to the ordinary laser light.

3.3 MEs as absorbing and emitting quantum antennae

3.3.1 How massless extremals generate coherent states of photons?

ME:s can be in 'dormant' or active state according to whether the em current associated with the ME is vanishing or not. In active state ME:s generate Bose Einstein condensate type state for ordinary photons. This means in TGD context the emission of (topological) vapour phase photons (CP_2 type extremals), which can condense on other condensate levels. ME:s generate gravitonic BE condensate and the possible biological role of this condensate will be discussed later.

Assuming that the coupling of quantized photon field to the massless extremal is given by regarding the massless extremal as a classical background field one obtains QED with a light like source J^α:

$$\begin{aligned} D_\beta F^{\alpha\beta} &= eJ^\alpha \ , \\ J^\alpha &= Jk^\alpha \ . \end{aligned} \tag{5}$$

The system is equivalent with an infinite number of harmonic oscillators each driven by a harmonic external force and a basic exercise in the quantum mechanics shows that the solutions of the field equations give the new oscillator operators as sums of free oscillator operators plus c-number term, which is essentially the Fourier component of the light like current in the direction of the polarization.

In the limit that ME has infinite duration and is a cylindrical structure of finite length L (that is micro-tubule) one has for $J \propto sin(k_z(t-z))$

$$\begin{aligned} a^\dagger(p) &\rightarrow a^\dagger(p) + g(p) \ , \\ g(p) &= \sum_n \delta(p^0, k^0_n) K(p, k_n) J(k^z_n, p_T) \ , \\ K(p,k) &= \epsilon(p) \cdot k \frac{1}{i(p_z - k_z)} (exp(ip_z L) - 1) \ , \\ k_n &= nk_0 = \frac{n2\pi}{L}(1,1,0,0) \ . \end{aligned} \tag{6}$$

Here p denotes the momentum of the photon and k the 4-momentum associated with the Fourier component of a light-like current. $\epsilon(p)$ denotes the polarization of the photon. $J(k^z_n, p_T)$ is essentially the 3-dimensional Fourier transform of the scalar function J. The infrared behavior of $J(k_z, p_T)$ as a function of the transversal momentum p_T can be deduced from the fact that the transverse dimension of the micro-tubule is small (about 25 nm) as compared to $1/p_T$ so that the Fourier component is in good approximation independent of p_T.

For the frequencies present in the Fourier decomposition of the massless extremal, the ordinary oscillator vacuum is transformed to a coherent state in the corresponding Fourier mode of the quantized photon field. The essential point is that the wave vectors of the radiation field and massless extremal are nonorthogonal. The radiation pattern resembles the ordinary antenna pattern associated with an oscillating current $J(t) = exp(i\omega t)$ in that the intensity of radiation vanishes at angles $\theta = \pi/2$ and $\theta = 0$. For $J \propto sin(k_z(z-t))$ $|K|^2$ has maxima for $\theta = 48.6$ degrees and 131.4 degrees. For an ordinary dipole with $J = sin(\omega t)$, $\omega = 2\pi/L$ the radiation pattern is concentrated at angles $\theta \geq 40$ degrees with maximum and 69.3 degrees and 110.7 degrees.

A more complicated situation corresponds to a group of several massless extremals (say microtubules). If massless extremals are parallel and have same length the previous expression generalizes with superposition of terms

$$g(p) \quad \rightarrow \quad \sum_n exp(i\phi_n) exp(ip_z z_n) exp(ip_T \cdot x_T) g_n(p) \quad . \tag{7}$$

The phase ϕ_n is the phase difference between n:th light like current with respect to some reference current. If the positions of micro-tubules and/or phases of the individual light like currents are suitably chosen then various terms interfere constructively and macroscopic quantum coherence is obtained at resonant frequencies. Suffice it so say that the needed timing is extremely accurate: less than 10^{-12} seconds! Since p_z is small rather larger transversal distances are allowed by the requirement of constructive interference. In a more general situation also the orientations of microtubules can vary in certain limits. Note that light-like energy momentum generates also gravitonic BE condensates at preferred frequencies.

3.3.2 Massless extremal is accompanied by a Bose-Einstein condensate of parallel photons

The interaction Lagrangian describing the interaction of photon field with the light-like vacuum current does not couple to the photons collinear with the vacuum current (light-like wave vector has vanishing length squared). Therefore the ground states of the system are degenerate since one can add to any coherent state generated by the vacuum current any number of photons collinear with the vacuum current and topologically condensed inside the massless extremal. This means Bose-Einstein condensation in collinear degrees of freedom.

Collinear Bose-Einstein condensates of photons are crucial for the model of the quantum correlates of the sensory qualia. Sensory quale is characterized partially by the BE condensate of photons associated with the massless extremal parallel to the axon. The existence of the BE condensate makes possible induced emission. For instance, Josephson currents generate photons with frequencies which are multiples of the Josephson frequency. If the potential difference in Josephson junction equals to a multiple of the cyclotron frequency of some super conducting ion, the current flows resonantly in the sense that Josephson current serves as a harmonic perturbation generating quantum jumps and gives rise to a large dissipative current and also quantum jumps in either super conductor. Since the emission rate for photons by the current is proportional to N^2, where N is the number of photons already in the state, the presence of the BE condensate of photons with this frequency amplifies the emission rate. This kind of resonance mechanism is assumed in the model of sensory experience since it elegantly explains why given neuron corresponds to single quale. Since the potential difference over the Josephson junction can correspond to only single cyclotron frequency, the dominance of single quale is unavoidable even when all macroscopic quantum phases are present.

The existing BE condensate increases the probability of topological condensation of coherent photons generated by other massless extremals to the massless extremal. This mechanism could provide inter-neuronal communication mechanism and realize the metaphor about brain as a society

of neutrons, the notion of neuronal window idea and also give a more precise content to the music metaphor. In particular, neurons far away from each other could communicate using wavelengths in a narrow wave length range by this mechanism.

The wave vectors of the photons are multiples of $k = \pi/L$. This means that the length of the massless extremal correlates with the maximal allowed wavelength. For ELF photons associated with EEG frequencies of order 10 Hz the length of massless extremal is of order Earth's circumference. This suggests that more general massless extremals with a topology of torus instead of linear topology could characterize the topological field quanta of ELF fields. It is however impossible to say, whether the field equations allow more general solutions resembling massless extremals.

3.4 Quantum holography and quantum information theory

Sokolov and collaborators [17] have proposed a model of quantum holographic teleportation in which the *classical* photocurrents from the sender to receiver take the role of a dynamical hologram. The connection with MEs is obvious.

1. MEs are carriers of classical light-like vacuum currents (one of the basic differences between TGD and Maxwell theory). This suggests that MEs could be interpreted also as *classical* holograms, which are *dynamical* as in quantum information theory. Light-like current would be like a dynamical (four-dimensional) diffraction grating. Light-like vacuum currents and vacuum Einstein tensor generate also coherent states of photons and gravitons and MEs serve as templates for the topological condensation of photons and gravitons to the Bose-Einstein condensate of photons collinear with ME. The Bose-Einstein condensation of collinear photons and their generalizations to colored configuration space photons should affect the vacuum current by adding to the reference current what might be called evoked response. This condensation process could generate conscious experience and higher level qualia. Thus it would seem that MEs have a triple role as receiving and sending quantum antennae as well as classical holograms.

2. The proposal of [17] generalizes to the case of MEs provided one can device a method of coding quantum states of photon field to the vacuum currents. The high efficiency photodetector matrix is in which each pixel gives rise to a photocurrent [17], is replaced with ME or set of parallel MEs. The neural window hypothesis [H4] states that neuronal axons are accompanied by parallel MEs carrying information between sensory organs and brain and various parts of brain. This is only a less standard manner to say that ME represents classical dynamical hologram. The possibility of local light-cone coordinates allows also MEs which define curved deformations of the simplest cylindrical MEs.

   The concrete realization of holographic teleportation proposed in [17] brings strongly in mind the architecture of the visual pathways. Thus one can wonder whether brain is perfoming internal teleportation of photonic quantum states with spike patterns being directly coded to the pattern of the vacuum currents flowing along MEs. If spike patterns code the dynamical hologram, a surprisingly close relationship with Pribram's views about hologrammic brain results. Nerve pulse patterns could be seen as specifying the necessary classical aspects of the quantum teleportation (in TGD classical physics is essential part of quantum physics, rather than some effective theory).

3. Vacuum current at a 3-dimensional time-like section of ME as a function function of time defines a dynamical 3-dimensional hologram. This is consistent with the fact that our visual experience is two-dimensional: the information is always about outer boundaries of the objects of the perceptive field. The values of the vacuum current at a given point are non-deterministic which means that vacuum current is ideal for coding information. Classical

data also propagate without dispersion with light velocity obeying the laws of geometric optics and MEs imply channelling so that MEs are taylor-made for classical information transfer.

4. Space-time sheets can have both positive and negative time orientations and the sign of energy depends on time orientation in TGD framework. This means that classical communication can occur both in the direction of the geometric future and past: this is essential for the classical model of the long term memories as a question communicated to the geometric past followed by answer. The dynamical nature of the holograms means that there is no need to combine 2- or 3-dimensional holograms associated with several moments of geometric time to single hologram. To remember is to perceive an object located in the geometric past. Of course, fractality might make possible temporally scaled down versions of the geometric past but the principle would remain the same.

5. Quantum hologram view suggests that the super-canonical representations at the light-like boundaries of MEs characterized by gigantic almost-degeneracies are the real carriers of biological information. According to the general theory of qualia [K3] this information would become conscious since elementary qualia would correspond to quantum jumps for which increments of the quantum numbers correspond to the quantum numbers labelling super-canonical generators in the complement of Cartan algebra. In this view super-conducting magnetic flux tubes could perhaps be seen as intermediate level in the control circuitry controlled by MEs and controlling atomic level.

6. This picture leaves open whether there is a level controlling the thicknesses of the magnetic flux tubes and thus also magnetic transition frequency scales, and what this level might be. The entrainment of the endogenous frequencies to exogenous frequencies [K5] explains water memory and the effects of homeopathic remedies [47] and could make possible also endogenous NMR spectroscopy and chemical senses. The key to the puzzle might be a purely mathematical problem: how the boundary conditions at the boundaries of the magnetic flux tubes can be satisfied? It might be that the induced metric must become degenerate at the boundaries ($\sqrt{g} = 0$) implying a degeneracy of the induced metric at the boundary of the magnetic space-time sheet. This need not however mean that the M^4_+ projection of the boundary is a light-like surface: the projection could well be completely static. This supports the view that the boundaries do not carry super-canonical representations, which are associated with the imbedding space projection of the boundary rather than the boundary itself. One can imagine that ME with the same transversal section as magnetic flux tube is glued to the magnetic flux tube along this section: this kind of gluing results in a singular 4-surface analogous to the vertex region of Feynmann diagram and somekind of smoothing-out procedure is needed. The smoothed-out vertex region would make possible for ME to control magnetic flux tube thickness by varying its own transversal thickness.

3.4.1 MEs as quantum holograms in the sense of quantum gravitation

Quantum holography principle naturally generalizes to an approximate principle expected to hold true also in non-cosmological length and time scales.

1. The most general ansatz for MEs (inspired by the quantum holographic thinking) relies on the introduction of the notion of local light-cone coordinates S_+, S_-, E_1, E_2. The gradients ∇S_+ and ∇S_- define two light-like directions just like Hamilton Jacobi functions define the direction of propagation of wave in geometric optics. The two polarization vectori fields ∇E_1 and ∇E_2 are orthogonal to the direction of propagation defined by either S_+ or S_-. Since also E_1 and E_2 can be chosen to be orthogonal, the metric of M^4_+ can be written locally as

$ds^2 = g_{+-}dS_+dS_- + g_{11}dE_1^2 + g_{22}dE_2^2$. In the earlier ansatz S_+ and S_- where restricted to the variables $k \cdot m$ and $\tilde{k} \cdot m$, where k and $\tilde{k}$ correspond to light-like momentum and its mirror image and m denotes linear M^4 coordinates: these MEs describe cylindrical structures with constant direction of wave propagation expected to be most important in regions faraway from the source of radiation.

2. Boundary conditions are satisfied if the 3-dimensional boundaries of MEs have one light-like direction (S_+ or S_- is constant). This means that the boundary of ME has metric dimension $d = 2$ and is characterized by an infinite-dimensional super-canonical and super-conformal symmetries just like the boundary of the imbedding space $M_+^4 \times CP_2$: The boundaries are like moments for mini big bangs (in TGD based fractal cosmology big bang is actually replaced with what might be called a silent whisper amplified to not necessarily so big bang). Quantum holography would mean that effectively 2-dimensional conformal field theory at the boundary of M_+^4 region determined by ME determines what happens in the interior at QFT limit when space-time surface is not regarded as a dynamical object.

3. These observations inspire the conjecture that boundary conditions for M^4 like space-time sheets fixed by the absolute minimization of Kähler action quite generally require that space-time boundaries correspond to light-like 3-surfaces with metric dimension equal to $d = 2$. Quantum holography principle would state that the dynamics related to the metric of the configuration space, that is genuine quantum gravitation, would reduce to the boundaries of space-time sheets. The dynamics in zero modes and quaternion conformal degrees of freedom crucial for elementary particle physics would not however allow this kind of reduction. This would be consistent with the fractality which is expected to be a basic characteristic of the quantum critical Universe predicted by TGD. The approximate super-canonical and conformal symmetries would be associated with the light-like boundaries of the space-time sheets. Super-canonical invariance would be broken only by quantum gravitational effects at the level of the configuration space by the fact that the boundaries of space-time surfaces are actually dynamical rather than fixed. The cosmological light-cone boundary would be however non-dynamical and this would guarantee the exactness of the cosmological super-canonical invariance.

3.4.2 More concrete view about MEs as holograms

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1. MEs are carriers of classical light-like vacuum currents (one of the basic differences between TGD and Maxwell theory). This suggests that MEs could be interpreted also as *classical* holograms, which are *dynamical* as in quantum information theory. Light-like current would be like a dynamical (four-dimensional) diffraction grating. Light-like vacuum currents and vacuum Einstein tensor generate also coherent states of photons and gravitons and MEs serve as templates for the topological condensation of photons and gravitons to the Bose-Einstein condensate of photons collinear with ME. The Bose-Einstein condensation of collinear photons and their generalizations to colored configuration space photons should affect the vacuum current by adding to the reference current what might be called evoked response. This condensation process could generate conscious experience and higher level qualia. Thus it would seem that MEs have a triple role as receiving and sending quantum antennae as well as classical holograms.

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a light-like surface: the projection could well be completely static. This supports the view that the boundaries do not carry super-canonical representations, which are associated with the imbedding space projection of the boundary rather than the boundary itself. One can imagine that ME with the same transversal section as magnetic flux tube is glued to the magnetic flux tube along this section: this kind of gluing results in a singular 4-surface analogous to the vertex region of Feynmann diagram and somekind of smoothing-out procedure is needed. The smoothed-out vertex region would make possible for ME to control magnetic flux tube thickness by varying its own transversal thickness.

3.4.3 MEs and super-canonical and super-conformal symmetries

TGD predicts two kinds of super-conformal symmetries [E2]. Quaternion conformal symmetries correspond to the gauge symmetries of fundamental interactions. Cosmological super-canonical symmetries act on the boundary of light-cone and are cosmological symmetries.

The non-determinism of Kähler action however implies that the light-like M^4_+projections of light-like boundaries of MEs take the role of the boundary of future light-cone as quantum holograms and super-canonical symmetry becomes ordinary macroscopic symmetry. Thus there is a fractal hierarchy of quantum holograms inside quantum holograms. One can identify the light-like boundaries of MEs as geometric correlates for selves. Also space-like selves are very probably needed and magnetic flux tube structures could represent them. Indeed, the non-determinism of CP_2 type extremals representing elementary particles (their M^4_+ projections are random light-like curves) makes it impossible to characterize the quantum state completely by the data on the light-like boundaries of MEs.

MEs are natural carriers of super-canonical representations obtained by multiplying ordinary physical states by configuration space Hamiltonians (functions of CP_2 coordinates and coordinates E_1, E_2 and S_+ or S_- which can obviously be arranged into irreducible representations of the color group $SU(3)$) and define an excellent candidate for a hierarchy of higher level life forms. The intuitive belief that quantum gravitation is crucial for higher level consciousness can be indeed justified in this framework: the 'worlds about worlds' aspect of higher level consciousness is what requires genuine quantum gravitational states.

The boundary of ME having one light-like direction gives rise to conformal quantum hologram representing quantum correlation functions for quantum field theory defined in the interior of ME. This 3-dimensional dynamical quantum hologram should code for conscious information about external world. This information could be determined by coherent light and gravitons scattered from the outer boundaries of other space-time sheets and could provide a quantum representation for the geometry of the boundaries of the other space-time sheets.

Super-canonical degrees of freedom makes MEs ideal candidates for the correlates of higher level consciousness.

1. The states of super-canonical representations have gigantic almost-degeneracies broken only by non-commutativity of super-canonical and Poincare symmetries which means huge information storage capacities. Super-canonical representations can be realized in real context using Bose Einstein condensates of massless elementary particles on MEs. Super-canonical representations correspond to genuine quantum gravitational effects since wave functionals in the space of three-surfaces are involved: space-time ceases to be a passive arena of quantum dynamics. In fact, canonical transformations of CP_2 are approximate symmetries of the theory broken only by classical gravitation. The notion of 'configuration space photon' having nontrivial dependence on configuration space degrees of freedom characterized by Hamiltonian suggests strongly itself and seems to be crucial for understanding of the visual colors.

2. Super-canonical representations have universal transition frequency spectrum given as multiples of the fundamental frequency determined by the length of ME. If one assumes that MEs have lengths given by p-adic length scale hypothesis, fundamental frequencies turn out to correspond to important resonance frequencies in EEG.

For these reasons super-canonical representations are ideal candidates for an infinite hierarchy of life forms associated with MEs. The great vision is that MEs and magnetic super-conductors associated with the magnetic flux tube structures form a fractal hierarchy interacting with the ordinary bio-matter via the classical gauge fields associated with MEs [K3, M3, M4, M5].

The standard manner to see the evolution of organism is as an initial value problem with data given at time=constant space-like section of Minkowski space. This view is definitely wrong in TGD framework, where the classical non-determinism of Kähler action is absolutely essential for the understanding of bio-systems and consciousness. Rather, one should see the problem as a boundary value problem with data given at light-like surfaces bounding MEs analogous to light-cone boundary identifiable as the moment of big bang. This view conforms nicely with the active intentional aspects of the biological evolution: system can decide what it will be and life is more like a narrative with definite goals than random Brownian zigzag curve. The life cycle of the organism is specified by posing some requirements which it must satisfy in the form of boundary conditions and organism does it best to satisfy them.

3.4.4 Mechanism for generation of configuration space photons

The super-canonical representations should have some interaction mechanism with ordinary matter, if they are to be important for life. In particular, a mechanism making MEs to emit and absorb configuration space photons coupling to em charge, should exist. There are good reasons to expect that direct couplings between exotic super-canonical states and ordinary elementary particles are very weak. The quantum number $L_0 = n$ defined by the Virasoro generator $L_0 = zd/dz$ (complex scaling) acting effectively as Hamiltonian in string diagrams is conserved in vertices. For matter representations massless ground states correspond have scaling quantum number $n = n_0$, where n_0 defines the negative value of the vacuum weight. It must be emphasized that for super-canonical representations L_0 does not seem to allow the interpretation as mass squared operator as in the case of quaternion conformal representations. The vertices in which $L_0 = O(p^k)$ state emits ordinary particle correspond to $np^k \leftrightarrow (np^k - m_0) + (m_0)$. The intermediate state is with $L_0 = np^k - m_0$ is has ultralarge scaling quantum number so that the amplitude is suppressed by a huge propagator factor. The processes involving only $L_0 = O(p^k)$ states are however not suppressed.

The interaction of the exotic super-canonical states with the classical gauge fields associated with MEs provides a unique mechanism of 'matter-mind interaction'. The vanishing of the vacuum weight of Super Virasoro is very much analogous to the vanishing of the Higgs vacuum expectation value in ordinary gauge theories. Indeed, the exotic super-canonical representations have unbroken gauge symmetries, which means that electro-weak and color interactions occur like in symmetry-nonbroken unconfined gauge theory. The presence of long range classical color and electro-weak gauge fields implying unbroken symmetries at classical level is important part of the story.

MEs have already at the space-time level symmetries supporting the view that super-canonical algebra acts as isometry algebra of the configuration space.

First, canonical transformations of $E^2 \times CP_2$, where E^2 is plane orthogonal to the light-like wave vector k associated with ME, are symmetries of MEs. Also canonical transformations made local with respect to the light-like coordinate u and coordinate variable v orthogonal to u are also symmetries.

Secondly, arbitrary dependence on the variable u is equivalent with the invariance with respect to hypercomplex analytic transformations

$$x + ey \rightarrow f(x + ey) \ ,$$

$$e^2 = 1 \ .$$

where f is arbitrary function. These transformations obey Lie-algebra which is essentially identical with the Virasoro algebra spanned by the infinitesimal holomorphic transformations.

The general interaction Hamiltonian for this interaction can be guessed by recognizing the following facts.

1. Interaction Hamiltonian should have the general current-vector potential form

$$H_{int} = \sum_D \int G^A_\mu(D) J^{A\mu}(x|D) \sqrt{g_4} d^4x \ ,$$

where sum is over the representations D of color group defined by color Hamiltonians and where $G^A(D)$ represents analog of the classical gluon field associated with a particular color representation. In the case of color octet representation G^A_μ("8") represents classical gluon field and is simply the projection of the Killing vector field of the color isometry to the space-time surface. The obvious generalization is that also in general case the vector field defined by the color transformation defines the classical gluon field. $J^{A\mu}(x|D)$ is the local current defined as the superposition of canonical generators continued to a function of space-time coordinates.

2. The construction of a local current defined on entire space-time surface having super canonical generator as conserved charge is highly nontrivial task. It should be based on the observation that for ME there is a unique decomposition of M^4 tangent space to $M^4 = M^2 \times E^2$ such that E^2 is space-like plane orthogonal to the light-like wave vector k associated with ME. Let u denote the coordinate

$$u = k \cdot m \ .$$

The task is to continue the canonical generator localized with respect to the radial coordinate of the light-cone boundary to a function in entire M^4_+. A possible manner to do this is to multiply the generator by a plane wave

$$exp(i2\pi f(u - u_0)) \ ,$$

where u denotes the restriction of the coordinate u to the light-cone boundary

$$u_0 = u_{|\delta M^4_+} \ .$$

The task is to fix the physical identification of the ME frequency. It turns out that interpretation as energy is the most plausible identification.

It might well be that only classical color fields define interaction vertices leading to the generation of configuration space photons. If this is the case the octet representation for configuration space photons would have a unique role. This would explain why visual colors, which can be identified as counterparts of the charged Hamiltonians associated with configuration space photons, are in a special role. Furthermore, MEs have always 2-dimensional CP_2 projection and carry classical color fields and currents restricted to $U(1)$ sub-algebra of color algebra, which need not be however color neutral. This implies that only particular configuration space photon and its conjugate are emitted and that only single color is created by the BE condensation of configuration space photons generated by a particular ME on other MEs.

3.5 MEs and quantum control

3.5.1 MEs and classical de-coherence

TGD approach inspires the idea that classical de-coherence corresponds to the decomposition of a space-time sheet carrying superposition of em fields to separate space-time sheets carrying the em fields appearing in the superposition. Since em fields live at different space-time sheets, interference effects are indeed absent which means de-coherence. A more precise and rather far reaching form of this hypothesis is that classical em field is unstable against decomposition to MEs. This mechanism allows to understand what might happen when amplitude modulated em field acts with living matter in the experiments of Blackman [45].

The extreme nonlinearity of the dynamics of absolute miminization of Kähler action implies that ELF modulated radio frequency field induces also em field component with modulating ELF frequency. If classical de-coherence generates MEs then classical amplitude modulated em fields leads to the generation of a large number of MEs at various frequencies and directions of wave vector. For instance, modulation frequency and carrier frequency could correspond to different MEs glued to each other by 'wormhole contacts'. Classical de-coherence and geometrically realized Fourier analysis would be the geometric and classical counterparts for field quantization reflecting the fact that absolute minimization of Kähler action implies that space-time surfaces are analogous to Bohr orbits.

3.5.2 MEs and conscious holograms

The notion of conscious hologram is much more practical than the concept of quantum gravitational hologram and generalizes the notion of ordinary hologram by fusing it with the notion of self [K4]. Universe is an extremely complex fractal Feynmann diagram with lines replaced by 4-dimensional space-time sheets and MEs are particular kinds of lines analogous to photon lines. These lines are like laser beams, which interfere in the vertices of the Feynmann diagram: vertices correspond to material space-time sheets, atoms, molecules, ..., cells, ... The 3-D hologram vision corresponds at the level of conscious hologram stereo consciousness resulting when the mental images associated with different points of the hologram fuse to single mental image by quantum entanglement involving also the sharing of mental images.

An important piece of the picture is fact that MEs appear as pairs of high frequency and low frequency MEs. The low frequency MEs serve as correlates for remote quantum entanglement, now between different parts of brain. High frequency MEs travel like massless particles along the bridges defined by the low frequency MEs and serve as bridges between different space-time sheets at the receiving end. This induces a leakage of ions between different space-time sheets, breaking of super-conductivity and dissipative self-organization: this process which is analogous to the formation of hologram, is responsible for homeostasis and metabolism and gives rise to many-sheeted ionic flow equilibrium. Also many-sheeted lasers acting in a very wide range of frequencies become possible. The frequencies correspond to differences for the energies of ions at the space-time sheets involved. MEs parallel to axons can also act as Josephson junctions connecting space-time sheets which can correspond to different p-adic primes.

Phase conjugate laser beams have as their counterpart negative energy MEs and negative energy photons resulting in time reversal. The time reversal for the dissipation induced by super current leakage seems also to be a key mechanism of bio-control. This leads to the working hypothesis that negative energy MEs are responsible for motor control whereas positive energy MEs are involved with perception and cognition: motor action is time reversed sensory perception in appropriate p-adic time scale. Among other things negative energy MEs make possible emission of negative energies making possible buy now-pay later (or let others pay) mechanism and thus extreme flexibility of energy economy.

3.5.3 Many-sheeted ionic flow equilibrium controlled by MEs

A crucial empirical ingredient supporting the view about a hierarchy of magnetic super-conductors are the puzzling observations of cell biology (for a summary see the first chapter of [46]) challenging the association of ionic channels and pumps to cell membrane. The paradoxes disappear if cell and its exterior are assumed to be in a many-sheeted ionic flow equilibrium with ionic currents flowing from super-conducting space-time sheets to atomic space-time sheets and back, so that the densities of ions at atomic space-time sheets are controlled by the the very small densities and quantized currents of dark ions at super-conducting magnetic flux tube space-time sheets and coding the information about homeostasis of bio-matter [J3]. Also a reason why for liquid crystal and electret properties of bio-matter emerges and one can understand the function of electric circuitry associated with body [61].

In this picture ionic channels and pumps would play the role of sensors detecting the concentrations of various ions and membrane voltages. The dominant part of the ionic currents would flow between cell interior and exterior as (possibly dark) supra currents and would dissipate very little. The dominant part of the metabolic energy would be used to build-up of dark EEG with photon energies above thermal threshold. Also negative dark W MEs responsible for motor actions would suck metabolic energy.

W MEs connecting magnetic body and biological body can induce charge entanglement by superposition of pairs of exotically ionized states with opposite exotic charges. State function reduction then selects either of the resulting states. Exotic ionization generates dark plasma oscillations which induce by Faraday law electric fields at the space-time sheets of the ordinary matter. The resulting ohmic currents in turn realize the control action on the ordinary matter (nerve pulse patterns, Ca^{2+} waves, etc...).

Neutral MEs can induce supra currents in super-conducting magnetic circuits by magnetic induction mechanism, serve as Josephson junctions between magnetic flux tubes, and induce magnetic quantum phase transitions. MEs can generate reference waves or their phase conjugates (time reversals) acting on lower level MEs serving as dynamical holograms. The induced coherent light pattern and its phase conjugate could act as a control command and its time reversed version. Conjugate reference waves provide an extremely simple mechanism of healing by time reversal allowing the living matter to fight against second law.

MEs could "read" DNA strand to the light-like vacuum current by moving along it and thus code DNA strand/conjugate strand to a hologram or its phase conjugate in turn acting as a control command or its time reversal. ELF MEs could do the same at the level of axons: instead of DNA sequences nerve pulse patterns would be read now. Thus living matter could be regarded as a symbiosis in which MEs control super-conducting magnetic flux tubes controlling ordinary matter at atomic space-time sheets via many-sheeted ionic flow equilibrium. DNA would represent the ROM of this system.

What makes this so interesting is that MEs are at the highest level of quantum control in the TGD based view about bio-system as a symbiosis in which MEs control super-conducting magnetic flux tubes controlling ordinary matter at atomic space-time sheets via many-sheeted ionic flow equilibrium. The coherent light pattern emitted by ME resulting from the interaction of ME with the reference wave (its phase conjugate) could act as a control command (time reversed control command) inducing process (time reversed process). Conjugate reference waves would thus provide an incredibly simple and general mechanism of healing by time reversal allowing the living matter to fight against second law. This would be like a general initiating a war by just nodding or shaking his head.

The formation of the phase conjugates could occur completely routinely and explain also why DNA appears in double strands. ME could read DNA strand to the pulse pattern of the light-like vacuum current by moving along the strand and thus code DNA strand (conjugate strand) to a hologram (its phase conjugate) in turn acting as a control command (its time reversal). ELF MEs

could do the same at the level of axons: instead of DNA sequences nerve pulse patterns would be read now. DNA would clearly represent the ROM of this system. The coding of proteins would thus not be the only function related to DNA: DNA would be for the cell society what the first written laws were for human society, and the presence of the conjugate strand would make possible a systematic self repair at the cellular level by time reversal. More detailed considerations along these lines, in particular some empirical evidence for the hologrammic realization of the genetic code in terms of light-like vacuum currents, are represented in [H8].

3.5.4 MEs as Josephson junctions?

MEs can induce Josephson junctions between bio-structures. Since the electric field of ME is orthogonal to the direction of the propagation of vacuum current, the Josephson junction with potential difference is formed most naturally when super conductors are joined by join along boundaries bonds to ME in the direction of the electric field associated with ME. MEs can in principle be arbitrary thin so that the thickness of Josephson junction can be much smaller than the dominating wavelength of ME.

ME electric field can contain also constant component. In this case is however ME is necessary double sheeted since constant electric field is created by wormhole throats on boundaries of ME serving as effective charges. These MEs could give rise to the Josephson junctions with constant potential difference. An attractive hypothesis is that these ME pairs have opposite time orientations so that total energy of ME pair can vanish and can be created from vacuum without any energy cost. Clearly, these structures are cognitive in the strong sense of the word.

This coding of the transversal potential difference associated with ME pair to Josephson frequency is expected to be fundamental information coding mechanism in living matter. ME pair can contain also oscillating electric field over Josephson junction at magnetic or some other transition frequency so that MEs are ideal for control purposes.

3.5.5 MEs and the interaction of the classical em fields with bio-matter

MEs acting as Josephson junctions and containing oscillating em field at ELF frequency give rise to a harmonic perturbation inducing quantum jumps of the magnetic states of ions and explains the effect of ELF em fields on bio-matter. Also the presence of the mysterious intensity windows [43, 45, 44] can be understood. Josephson current paradigm allows to understand this effect if RF or MW MEs associated with the external field act as Josephson junctions.

1. The external electric field oscillating with frequency ω (now radio frequency) defines slowly varying potential difference over Josephson junction of length d acting as Josephson junction provided that the condition

$$\omega \ll \omega_J(max) = ZeV = ZeEd$$

holds true. This gives

$$d \gg \frac{\omega}{ZeE} \quad .$$

For $E \sim .1$ V/m and $\omega \sim GHz$ which are typical values used in experiments [45], this condition gives $d \gg 10^{-6}$ meters which is satisfied if Josephson junctions have size not smaller than cell length scale.

2. For fixed length of Josephson junction amplitude window results if the maximal Josephson frequency $\omega_J(max)$ is slightly above some transition frequency since in this case the stationary maxima and minima of amplitude lead to long lasting resonant excitation of quantum

transitions. Denoting the relative width of the resonance by $\Delta\omega/\omega = P$, the ratio of the time spent in resonance at $\Omega_J(max)$ to the time spent off resonance at Ω_J is of order

$$\frac{t(max)}{t} \sim \sqrt{1 - \frac{\Omega_J^2}{\Omega_J^2(max)}} \times \frac{1}{\sqrt{P}} \ .$$

For a narrow resonance width this ratio can be very large so that amplitude window results for fixed value of d.

3. Amplitude window results if there is a correlation between the thickness of ME and transversal electric field so that $\omega_J(max) = ZeEd(E)$ satisfies resonance condition for some values of E only, if any. In absence of this correlation Josephson junctions must have discrete spectrum of effective lengths for amplitude window to result.

4. For electric fields in the range .1 V/m the frequencies ω_J are above GHz for d larger than 3×10^{-5} meters and correspond to the frequencies for the conformational dynamics of proteins. There are obviously a large number of frequencies of this kind and several intensity windows. EM fields with these strengths should have special effects on living matter: it could be even that some kind of feature recognition process involving self-organization occurs at these field strengths. Note that the minimal size of Josephson junctions corresponds to the p-adic length scale $L(173) \simeq 1.6 \times 10^{-5}$ meters characterizing structures next to cells in the p-adic length scale hierarchy.

3.5.6 The interaction of MEs with super-conducting magnetic flux tubes

The interaction of brain with MEs could mean that the super-conducting magnetic fluxtube circuitry associated with brain effectively acts as magnetometer somewhat in the same way as SQUID magnetometer measures the magnetic fields generated by brain. The resulting conceptual framework makes it easier to develop a quantum level model for the generation of nerve pulse and for the interaction of MEs and bio-super-conductors in terms of Josephson currents and super currents and relying on the notion of stochastic resonance.

Brain could measure the magnetic fields of MEs by using a mechanism which is very much like the mechanism of SQUID based magnetometers [18] used to measure the magnetic fields induced by brain.

1. A large collecting circuit in which the magnetic field of ME generates a compensating current by the quantization of the magnetic flux might be involved.

2. The amplification of this field could be achieved if the circuit contains a part which is spiral like and contains large number of loops in a small area.

3. In the core region the current flowing in the loop gives rise to an amplified magnetic field which in turn can penetrate into a super-conductor in form of flux tubes and in multiples of flux quantum. By counting the number of flux quanta one obtains rough measure for the magnetic field. In the case of brain the quantized magnetic flux would directly affect the state of neurons and the model for the generation of nerve pulse specifies this interaction. This effect on neurons would be long lasting as compared with the short-lasting action induced by the nerve pulse patterns.

4. The deviation of the flux of the amplified magnetic field from an integer number of flux quanta could be measured by a neuronal counterpart of SQUID, which basically consists of a closed loop decomposing to two parts which are joined together by insulator so that current rapidly

dissipates to a minimum value forced by the flux quantization. The current in SQUID serves as a measure for very weak magnetic fields of MEs. The non-linear dynamics of SQUID allows also stochastic resonance allowing to amplify very weak periodic signals. This measurement mechanism might be interpreted as a mechanism of interaction between super-conducting magnetic flux tubes and neuronal circuits inducing also an interaction between MEs and neuronal circuits. One might guess that nerve pulse generation might involve this kind of mechanism: stochastic resonance seems to be indeed involved but not in this manner.

The collecting circuits for the neuronal SQUIDs could be of order body size or even larger. In [K3] I have proposed the notion of magnetic circulation analogous to blood circulation to be a basic control system in bio-systems. This circulation could be seen also as a collecting circuitry for magnetic flux amplified in brain, where amplifying and SQUID type components of the circuitry are located. Amplifying and SQUID type parts of the circuitry might be also located in other organs like heart: perhaps even muscles contain amplifying circuits and neuronal SQUIDs. One cannot exclude the possibility of much larger collecting circuits making possible the control of the organism by the higher levels of self hierarchy.

The spiral loops used in SQUIDs to amplify the magnetic field bring in mind the spiral structures associated with the self-organizing excitable media [48]. I have proposed in [I4, I5] that spiral structures might in TGD framework correspond to magnetic or Z^0 magnetic flux tubes which enter along the first space-time sheet to the vertex of the spiral structure, flow to the second space-time sheet, and return along the spiral loop. These spiral loops could be also ionic em or Z^0 super-conductors. This kind of spiral loop might perhaps serve as an amplifier of the magnetic flux generated by the super current flowing along the loop.

Very general empirical inputs [46] in dramatic conflict with the standard vision about what homeostasis between cell interior and exterior means, lead naturally to a model in which the interaction of MEs with neuron occurs via magnetic induction mechanism leading also to the generation of nerve pulses. The notion of flow equilibrium in the many-sheeted space-time is essentially involved. The mechanism can also involve stochastic resonance as a means of transforming the oscillatory motion of the gravitational pendulum serving as an analog system to a rotational motion. The necessary noise could correspond to the noisy part of the super current perhaps induced by the incoming nerve pulses.

3.5.7 Genetic code and color?

It is gradually becoming clear that the possibility of classical color gauge fields, the center of mass color degrees of freedom of space-time sheets analogous to rigid body degrees of freedom, and configuration space color might have deep implications for the understanding of living matter and consciousness. Colored MEs, or what what might be called configuration space photons, are one possible candidate for colored particles involved with the realization of color vision. They might be also an essential element of bio-control using the analogs of laser beams and there phase conjugates to represent control commands and their time reversals. This raises the question whether color might relate somehow with the realization of genetic code. The following speculations are just first speculations but might help to open gates of imagination.

1. Minimal translation of the genetic code to holograms

Configuration space photons represent genuinely quantum gravitational states, state functionals in the 'world of worlds', and thus they should correspond to highest level of self hierarchy and perform quantum control. Since color and polarization represented as angular momentum component in direction of ME characterize configuration space dependence, they could play a fundamental role in the control mechanism and control commands represented by quantum holograms should

be characterized by a collection of these quantum numbers. In particular, genetic code might be expressible in terms of these basic quantum numbers.

There is a thought provoking connection with the TGD based model of genetic code predicting entire hierarchy of genetic codes.

1. At the first interesting level one has 4 nucleotides corresponding to $2^2 = 4$ mutually consistent statements in the set of $7 = 2^3 - 1$ statements coded by 3 bits and one statement thrown away.

2. DNA triplets correspond to the subset of $2^6 = 64$ mutually consistent statements of $2^7 - 1 = 127$ statements coded by 7 bits with one statement thrown away. At the next level one has $2^{127} - 1$ statements and the number of the mutually consistent statements is $2^{126} = 2^{6\times 21}$. It is not an accident that 126 decomposes into the product of numbers 6 and 21, where 21 is the number of different aminoacids with stopping sign counted formally as an aminoacid.

What makes the bell ringing is the appearance of the number $6 = 3 + 3$ primary colors and their conjugates. Could the number of nucleotides in the DNA triplet and its conjugate somehow correspond to the 3 primary colors and their complementary colors somehow? Note that also the 2-dimensional configuration spin is involved, and has two symmetry-related values J and $-J$ (configuration space spin should be responsible for polarization sense). How could this correspondence be consistent with the idea about MEs generating coherent states of configuration space photons having configuration space color and spin and acting as control commands?

Consider first a minimal model in which, somewhat disappointingly, color is not necessarily needed.

1. The proposal of Gariaev and collaborators that DNA can be effectively regarded as a static sequence of laser mirrors [51] suggests a concrete guess for the coding of genes to sequences of MEs. In TGD framework laser mirrors could correspond to transversal MEs associated with DNA nucleotides. The requirement that two orthogonal polarizations are possible, implies that there must be a pair of mutually orthogonal MEs associated with each nucleotide and orthogonal to the DNA strand.

2. Configuration space spin of ME, which is 2-dimensional spin, is either J or $-J$ so that $2 \times 2 = 4$ spin combinations $(\pm J, \pm J)$ are possible for the pair of MEs. The four nucleotides A,C,T,G naturally code for these spin configurations and the reversal of spin orientations corresponds naturally to the conjugations $A \leftrightarrow T$, $C \leftrightarrow G$ conjugations. Clearly, this model does not require color.

2. How color could emerge in the translation of the genetic code to holograms?

Color does not code for anything in the minimal model of the genetic code, and one could realize the genetic code using non-colored configuration space photons having only polarization degree of freedom or even ordinary polarized coherent light. There are some motivations for color however.

Each hologrammic command should have time reversed version giving rise to the phase conjugate command. Color and spin conjugation is a very natural manner to represent this operation. The conjugate hologram is naturally associated with the conjugate DNA strand. This observation allows to considerably generalize the model by only requiring that MEs correspond to any of the six basic colors and that complementary nucleotides correspond to conjugate colors. This option raises the possibility that DNA code words, genes or some other sub-units of DNA strands could define color singlets. This would obviously provide a very elegant manner to decompose genetic text to subunits. A more general, and perhaps more plausible, manner to decompose genetic text to subunits is as tensor products of unentangled and irreducible color representations.

This option however allows the possibility that genetic codewords are self conjugate. What if one excludes this possibility? It is possible to exclude the possibility of self conjugate commands by using 3+3 decomposition of color algebra corresponding to colors and complementary colors. The pairs of MEs associated with the subsequent nucleotides could be assumed to correspond to, say, (red, blue, white) in this order so that the conjugate strand corresponds to (green, yellow, black). In fact, the ordering of the colors is not essential since spin states of MEs code for the information. At quantum level the requirement that three colors are different would boil down to the requirement that there is complete asymmetry with respect to the permutations of the colors of three parallel MEs. Note that in this case the color quantum numbers of the DNA strand or its complementary strand cannot sum up to zero.

Note that the three different colors for the subsequent nucleotides might make possible that the corresponding control commands act on different MEs, which could be MEs associated with DNA itself.

3. Color confinement and bio-control

If color is really there, it must have some crucially important function besides making it possible to define time reversals of the control commands and decomposition of DNA to unentangle linguistic subunits. A good guess is that color confinement is involved with this function very intimately. Color confinement in the length scale of DNA MEs requires color neutrality in this length scale. DNA strand and its conjugate, even triplet and its conjugate, can give rise to a color singlet state but this is not possible if only the MEs associated with DNA strand are activated. In this case color confinement requires that somewhere else another colored state is activated so that the resulting overall state is color singlet. Thus long range correlations in the length scale of MEs perhaps crucial for biological self organization are unavoidable.

The work of Gariaev and collaborators is based on effects associated with visible laser light interacting with DNA. This encourages to think that the lengths of DNA MEs should be of order $E-7-E-6$ meters. This conforms with the idea that genes should directly control the functioning of the cell or at least the cell nucleus. Note that genes might be regarded as longitudinally color entangled portions of DNA acting. Configuration space color entanglement in length scale of chromosome and nucleus could obviously be possible. If this picture is correct, color confinement would be much more, that an eternal nuisance of elementary particle theorist.

4. Also memetic codewords could be coded to holograms

One can imagine also the translation of the memetic code to a sequence of orthogonal ME pairs. The $6 \times 21 = 126$ bits for the maximal number of mutually consistent statements of the memetic code decompose into a sequence of 21 6-bit sequences interpreted as statements consisting of 21 words. Each 6-bit sequence consisting of three 2-bit units in turn is in one-one correspondence with a DNA triplet. Each 2-bit unit would code for the configuration space spins $\pm J$ for a a pair of orthogonal MEs possibly forming an antisymmetrized triplet of the basic colors. The duration of the memetic codeword corresponds to the secondary p-adic time scale $T_2(M_{127}) = .1$ seconds so that by Uncertainty Principle memetic code could imply long range color correlations in the length scale of Earth. ELF MEs propagating in phase with the nerve pulse sequence (this is essential and explains why ELF MEs must scan the cortex!) could translate the memetic codewords represented by the sequences of the cognitive neutrino pairs to quantum holograms.

3.6 Experimental evidence for MEs

There is indeed evidence for the presence of MEs in bio-system. In CASYS'2000 conference Peter Marcer reviewed the work done by him in collaboration with Russian group [51] led by Peter Gariaev providing experimental evidence for the hypothesis that DNA acts as a receiving and sending quantum antenna. What was observed that irradiation of DNA with visible laser light

induced emission of coherent light with both visible and radio frequencies. The emitted radiation was also modulated in time scale of about .01 seconds. The modulation could be due to propagation of soliton sequences propagating along Josephson junction formed by the strands of DNA or due to nonpropagating spatially constant Josephson current: both cases are mathematically equivalent with gravitational pendulum. Phantom DNA effect [52] has explanation in terms of mind like space-time sheets identifiable as MEs. The experiments of Russian group replicated the observations of Poponin.

With inspiration coming from the experimental results, Gariaev has also suggested that DNA is accompanied by a sequence of some kind of laser mirrors. TGD suggests their interpretation as MEs [51]. The assumption that each nucleotide is accompanied by an orthogonal pair of MEs (two orthogonal polarizations) allows a holographic realization of the genetic code. Four nucleotides are mapped to four pairs of values of the configuration spin $\pm J$ in the simplest realization [K3]. Color degrees of freedom would bring in the long term correlations forced by color confinement in the length scale of DNA ME, which should be of order of wavelength of visible light, and thus forcing structures of this size to behave like coherent units.

The bio-photons of Popp [53] could correspond to coherent photons generated by MEs. Homeopathy could also have explanation in terms of MEs coding relevant frequency information to MEs about medicine, whose effect is also based on MEs [J5]. MEs would simply mimic the medicine. There are well documented effects related to the ability of water to absorb and transmit frequencies [58]. The ability of water to absorb and transmit frequencies could rely on the generation of mind like space-time sheets, most naturally MEs, oscillating with the same frequency as stimulus. Water would form cognitive representation for the stimulus, mimic it, in terms of light-like vacuum current giving rise to classical em or Z^0 field providing nonlike hologram like representation for the stimulus.

MEs are predicted to form a scale invariant family and quite recent cosmological data provides support for MEs in cosmological(!) length scales [19]. An intense beam of photons with energies of roughly 100 proton masses from a blazar at distance of about 10^8 light years have been observed. Blazar is so called gamma ray burster producing extremely intense energy fluxes in form of two jets. How these jets are produced is mystery of its own in standard physics. In TGD these jets correspond to the ends of cosmic string decaying like a cosmic firecracker into ordinary matter giving rise to galaxies. What makes observation 'impossible' is that photons with these energies should never reach Earth but lose their energy via scattering with cosmic microwaves background. Somehow these photons are however able to defy laws of standard physics. One TGD based model for phenomenon is very simple: photons are Bose-Einstein condensed on and travel, not along material space-time sheet were energy would be rapidly lost, but along 'massless extremal' (ME) of cosmic size scale. Cosmic laser beam is in question. One can also consider the possibility that the light-like vacuum current associated with cosmic ME generates the observed photons.

The general model for quantum control and coordination relies crucially on the existence of a hierarchy of superconductors associated with the self hierarchy (self defined as a quantum system able to avoid bound state entanglement with environment) controlling the ionic densities at atomic space-time sheets via many-sheeted ionic flow equilibrium and being quantum controlled with the mediation of the fractal hierarchy of MEs.

4 Bio-systems as superconductors

TGD Universe provides also the hardware for the realization of bio-system, in particular brain, as a macroscopic quantum system involving various kinds of super conductors. The essential elements are quantum criticality, spin glass analogy and generalization of the space-time concept and TGD based gauge field concept.

4.1 General mechanisms for 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 un-necessary. 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.

A crucial element is quantum criticality predicting that superconductivity appears at the fluctuating boundaries of competing ordinary and large $\hbar$ phases for nuclei. This assumption predicts several anomalous phenomena such as cold fusion and nuclear transmutations. 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 walls are especially interesting candidates for supra current carries. In this case the Cooper pairs must have spin one and this is indeed possible for wormholy 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 works for electrons, protons, ions and even charged molecules so that an entire zoo of high T_c bio-superconductors and super-fluids is predicted. All atoms and ions can be regarded as completely ionized Z^0 ions and also Z^0 superconductors (or super fluids) are predicted.

1. The experimental data about the effects of ELF em fields at cyclotron frequencies of various ions in Earth's magnetic field on bio-systems [57] provide support for this scenario. Most remarkably, the cyclotron frequencies of biologically important ions correspond to the important frequencies of EEG and the time scale of nerve pulse corresponds to $n = 3$ multiple of proton cyclotron frequency so that a direct quantitative contact with brain consciousness results.

2. Electronic super conductors are of type II with defect regions being typically cylindrical: DNA sequences, proteins, microtubules,... could provide examples of the defect regions. One ends up also with a model of high T_c super conductors in which the interaction of the electrons with wormhole BE condensate gives rise to Cooper pairs. The model explains elegantly the basic peculiar features of the high T_c superconductors.

3. Long ranged Z^0 force due to anomalous weak isospin of nuclei [F8, F10] and Z^0 charged wormholes make possible also Z^0 ionic superconductivity and even dark neutrino super conductivity. For instance, Z^0 ionic superconductivity is crucial in the model for the quantum correlate of hearing: audible frequencies are mapped to Z^0 cyclotron frequencies. Dark neutrino super conductors are of type I in the interesting length scale range and defect regions are stripe like. Besides cell and endoplasma membranes, epithelial sheets consisting of two cell layers and some larger structures in cortex could correspond to regions of this kind and the interpretation as a physical realization of cognitive hierarchy suggests itself.

4.2 Superconductivity at magnetic flux quanta in astrophysical length scales

Magnetic flux tubes of endogenous magnetic field $B_{end} = 2B_E/5 = .2$ Gauss, where $B_E = .5$ Gauss is the nominal value of the Earth's magnetic field, are crucial for the TGD based model of superconductivity. Since the models of auroras assume that the magnetic flux lines act effectively as conducting wires, the natural hypothesis is that superconductivity is an astrophysical phenomenon. This leads to a model of auroras explaining the latest findings and providing further insights to the superconductivity and the manner how it breaks down. Critical temperature can be identified as the temperature at which the join along boundaries bonds making possible the leakage of the supra currents to the non-superconducting space-time sheets become possible and can be gigantic as compared to the temperature at the superconducting space-time sheets if space-time sheets are thermally isolated. On the other hand, the possibility of large $\hbar$ phases in principle makes possible arbitrarily high critical temperatures in a given length scale.

p-Adic length scale hierarchy and the hierarchy of dark matters labelled by values of $\hbar$ suggest the existence of an entire hierarchy of super conducting space-time sheets giving rise to a hierarchy of cognitive representations (abstractions about abstractions about...). The possibility of complex conformal weights expressible in terms of zeros of Riemann Zeta such that the net conformal weight is real, and the hierarchy of algebraic extensions of p-adic number fields suggest the existence of additional hierarchies.

4.3 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 [M3] 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 [38] 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 [M3]. 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.

4.4 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.

4.4.1 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.

4.4.2 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.

4.4.3 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

(8)

5 Many-sheeted space-time, universal metabolic quanta, and plasmoids as primitive life forms

In the following the evidence for many-sheeted space-time will be discussed.

5.1 Evidence for many-sheeted space-time

The dropping of particle to a larger space-time sheet liberates energy which is the difference of the energies of the particle at two space-time sheets. If the interaction energy of the particle with the matter at space-time sheet can be neglected the energy is just the difference of zero point kinetic energies. This energy depends on the details of the geometry of the space-time sheet. Assuming p-adic length scale hypothesis the general formula for the zero point kinetic energy can be written as

$$E(k) = x \times E_0(k) \quad , \quad E_0(k) = \frac{3}{2}\frac{\pi^2}{mL^2(k)} \quad .$$

Here x is a numerical factor taking into account the geometry of the space-time sheet and equals to $x = 1$ for cubic geometry.

The liberated zero point kinetic energy in the case that the particle drops to a space-time sheet labelled by $k_f = k + \Delta k$ with same value of x is

$$\Delta E(k, \Delta k) = x \times E_0(k) \times (1 - 2^{-\Delta k}) \quad .$$

The transitions are seen as discrete lines for some resolution $\Delta k \leq \Delta k_{max}$. At the limit $k \to \infty$ transitions give rise to a quasicontinuous band. The photon energy for $k \to \infty$ transition is same as the energy from $k - 1 \to k$ transition, which brings in additional option to the model building.

For a proton dropping from the atomic space-time sheet $k = 137$ to very large space-time sheet ($\Delta k \to \infty$) one has $\Delta E(k) = E(k) \sim x \times .5$ eV. Since the ratio of electron and proton masses is $m_p/m_e \simeq .94 \times 2^{11}$, the dropping of electron from space-time sheet $k_e = k_p + 11$ liberates zero point kinetic energy which is by is by a factor .9196 smaller. For $k_p = 137$ one would have $k_e = 148$. This energy corresponds to the metabolic energy currency of living systems and the idea is that the differences of zero point kinetic energies define universal metabolic energy currencies present already in the metabolism of pre-biotic systems. In the following fit electron's zero point kinetic energy will be taken to be $E_0(148) = .5$ eV so that for proton the zero point kinetic energy would be $E_0(137) = .544$ eV.

The hypothesis predicts the existence of anomalous lines in the spectrum of infrared photons. Also fractally scaled up and scaled down variants of these lines obtained by scaling by powers of 2 are predicted. The wavelength corresponding to .5 eV photon would be $\lambda = 2.48$ μm. These lines should be detectable both in laboratory and astrophysical systems and might even serve as a signature for a primitive metabolism. One can also consider dropping of Cooper pairs in which case zero point kinetic energy is scaled down by a factor of 1/2.

Interestingly, the spectrum of diffuse interstellar medium exhibits three poorly understood structures [20]: Unidentified Infrared Bands (UIBs), Diffuse Interstellar Bands (DIBs) [21], and Extended Red Emission (ERE) [24] allowing an interpretation in terms of dropping of protons or electrons (or their Cooper pairs) to larger space-time sheets. The model also suggests the interpretation of bio-photons in terms of generalizes EREs.

5.1.1 Unidentified Infrared Bands

Unidentified infrared bands (UIBs) contain strong bands at $\lambda = 3.3, 6.2, 11.3$ microns [20]. The best fit for the values of k and Δk assuming dropping of either electron or proton are given by the following table. The last row of the table gives the ratio of predicted photon energy to the energy characterizing the band and assuming $x = 1$ and $E_0(148, e) = .5$ eV. Discrepancies are below 8 per cent. Also the dropping of protonic Cooper pair from $k = 137$ space-time sheet could reproduce the line $\Delta E = .2$ eV. The fit is quite satisfactory although there is of course the uncertainty related to the geometric parameter x.

λ/nm	$E/.5eV$	k	Δk	$\Delta E(k, \Delta k)/E$	p/e
3300	.7515	137	$\sim \infty$	1.002	e
6200	.4000	138	3	1.067	e
11300	.2195	139	3	0.878	p
11300	.2195	139+11=150	3	1.076	e

Table 1. Table gives the best fit for UIBs assuming that they result from dropping of proton or electron to a larger space-time sheet and one has $E_0(148, e) = .5$ eV. The fourth column the table gives the ratio of predicted photon energy to the energy characterizing the band and assuming $x = 1$. e/p tells whether electron or proton is in question.

According to [20], UIBs are detected along a large number of interstellar sight-lines covering a wide range of excitation conditions. Recent laboratory IR spectra of neutral and positively charged poly-cyclic aromatic hydrocarbons (PAHs) has been successfully used by Allamandola [23] to model the observed UIBs. It is believed that PAHs are produced in reactions involving photosynthesis and are regarded as predecessors of biotic life [22]. This would conform with the presence of metabolic energy quanta.

DNA sugar backbone, some aminoacids, and various hallucinogens involve 5- and 6-cycles and the proposal is that these cycles involve free electron pairs, which possess Planck constant $\hbar = n\hbar_0$, $n = 5, 6$. These free electron pairs would explain the anomalous conductivity of DNA and would be an essential characteristic of living matter. The emergence of $n = 5, 6$ levels could be seen as the first step in the pre-biotic evolution.

5.1.2 Diffuse Interstellar Bands

There are diffuse interstellar bands (DIBs) at wavelengths 578.0 and 579.7 nanometers and also at 628.4, 661.4 and 443.0 nm. The 443.0 nm DIB is particularly broad at about 1.2 nm across - typical intrinsic stellar absorption features are 0.1 nm [20]. The following table proposes a possible identification of these lines in terms of differences of zero point kinetic energies. Also now the best fit has errors below 7 per cent.

λ/nm	$E/.5eV$	k	Δk	$\Delta E(k, \Delta k)/E$	p/e
628.4	3.947	$135 = 3^3 \times 5$	$\sim \infty$	0.987	p
661.4	3.750	$135 + 11 = 2 \times 73$	3	0.985	e
443.0	5.598	$134 = 2 \times 67$	2	0.933	p
578.0	4.291	$135 + 11 = 2 \times 73$	$\sim \infty$	0.986	e
579.7	4.278	$135 + 11 = 2 \times 73$	$\sim \infty$	0.984	e

Table 2. Table gives the best fit for DIBs assuming that they result from dropping of proton or electron to a larger space-time sheet. Notations are same as in the previous table.

The peak wavelengths in chlorophyll and photosynthesis are around 650 nm and 450 nm and would correspond to second and third row of the table.

5.1.3 The Extended Red Emission

The Extended Red Emission (ERE) [20, 24] is a broad unstructured emission band with width about 80 nm and located between 540 and 900 nm. The large variety of peak wavelength of the band is its characteristic feature. In majority of cases the peak is observed in the range 650-750 nm but also the range 610-750 nm appears. ERE has been observed in a wide variety of dusty astronomical environments. The necessary conditions for its appearance is illumination by UV photons with energies $E \geq 7.25$ eV from source with $T \geq 10^4$ K. The position of the peak depends on the distance from the source [24].

According to [20] the current interpretation attributes ERE to a luminescence originating from some dust component of the ISM, powered by UV/visible photons. Various carbonaceous compounds seem to provide a good fit to the observational constraints. However, the real nature of ERE is still unknown since most candidates seem to be unable to simultaneously match the spectral distribution of ERE and the required photon conversion efficiency.

1. Consider first the band 650-750 nm appearing in the majority of cases. The most natural interpretation is that the lower end of the band corresponds to the zero point kinetic energy of electron at $k = 135 + 11 = 146 = 2 \times 73$ space-time sheet. This would mean that the lines would accumulate near 650 nm and obey the period doubling formula

$$\frac{\lambda(k) - \lambda(\infty)}{\lambda(\infty)} = \frac{2^{-k}}{1 - 2^{-k}} \quad .$$

   By the estimate of Table 2 the lower end should correspond to $\lambda = 628.4$ nm with a correction factor $x < 1$ reducing the zero point kinetic energy. The reduction would be smaller than 4 per cent. $\Delta k = 3$ transition would correspond to 744 nm quite near to the upper end of the band. For $\Delta k = 2$ transition one has $\lambda = 867$ nm not to far from the upper end 900 nm. $\Delta k = 1$ corresponds to 1.3 μm.

2. For proton with $k = 135 = 146$ the energy band would shift by the factor $2^{11} m_e/m_p \simeq 1.0874$ giving the range (598,690) nm.

3. The variation for the position of the peak can be understood if the charged particles at the smaller space-time sheet can have excess energy liberated in the dropping to the larger space-time sheet. This excess energy would determine the position of the lower end of the band in the range $(540, 650)$ nm.

4. One should also understand the role of UV photons with energy larger than 7.25 eV. For proton the energy would be 8.76 eV. For proton the energy would be 8.76 eV. UV photon with energy $E \geq 8$ eV could kick electrons from large space-time sheets to $k = 144 = 146 - 4$ space-time sheet where they have zero point kinetic energy of 8 eV plus possible additional energy (for proton the energy would be 8.76 eV). One possibility is that these electrons drop first to $k = 145$ by the emission of ~ 4 eV UV photon and then to $k = 144$ by the emission ~ 2 eV photon corresponding to 650 nm line. The further dropping to larger space-time sheets would produce besides this line also the lines with longer wavelengths in the band.

   The energy of UV photons brings in mind the bond energy 7.36 eV of N_2 molecule and the possibility of metabolic mechanism using UV light as metabolic energy and based on the dissociation of N_2 followed by re-association liberating metabolic energy kicking protons or electrons to a smaller space-time sheet. For the $k \to k + 3$ transition of electron the energy would be 7 eV which suggests that this transition defines important metabolic energy quantum for living interstellar dust using dissociation and its reversal as basic metabolic mechanism.

5.2 Laboratory evidence for plasmoids as life forms

5.2.1 From dust to dust

The article *From Plasma crystals and helical structures towards inorganic living matter* of Tsytovich *et al* in August issue of New Journal of Physics provides new empirical support for plasmoids as living life forms. The results of article suggest that interstellar dust could behave like living matter in some respects: it could even have variant of genetic code. This is a really shattering finding and with single blow destroys the standard dogma about life as something purely chemical. It should also give also some headaches for those influental colleagues who have decided that it is necessary to accept the anthropic principle. Here is little popularization of the result.

SCIENTISTS have discovered that inorganic material can take on the characteristics of living organisms in space, a development that could transform views of alien life.

An international panel from the Russian Academy of Sciences, the Max Planck institute in Germany and the University of Sydney found that galactic dust could form spontaneously into helixes and double helixes and that the inorganic creations had memory and the power to reproduce themselves.

A similar rethinking of prospective alien life is being undertaken by the National Research Council, an advisory body to the US government. It says Nasa should start a search for what it describes as weird life - organisms that lack DNA or other molecules found in life on Earth.

The new research, to be published this week in the New Journal of Physics, found nonorganic dust, when held in the form of plasma in zero gravity, formed the helical structures found in DNA. The particles are held together by electromagnetic forces that the scientists say could contain a code comparable to the genetic information held in organic matter. It appeared that this code could be transferred to the next generation.

Professor Greg Morfill, of the Max Planck institute of extra-terrestrial physics, said: Going by our current narrow definitions of what life is, it qualifies.

The question now is to see if it can evolve to become intelligent. Its a little bit like science fiction at the moment. The potential level of complexity we are looking at is of an amoeba or a plant.

I do not believe that the systems we are talking about are life as we know it. We need to define the criteria for what we think of as life much more clearly.

It may be that science is starting to study territory already explored by science fiction. The television series The X-Files, for example, has featured life in the form of a silicon-based parasitic spore.

The Max Planck experiments were conducted in zero gravity conditions in Germany and on the International Space Station 200 miles above earth.

The findings have provoked speculation that the helix could be a common structure that underpins all life, organic and nonorganic.

To sum up the essentials, plasma phase is involved and the dust life is able to construct analogs of DNA double helices and this has been achieved also in laboratory. "From dust to dust" seems to have a very deep side meaning!

Here is a more quantitative summary of the results reported in [30].

1. The scale of the dust balls seems to be few micrometers. It is essential that the system is open in the sense that there is both metabolic energy feed and continual feed of plasma to negatively charged dust particles to preserve their charges. Authors speak about effective "gravitational" instability as a mechanism leading to the formation of the helices and identify effective gravitational coupling (the formula contains a trivial typo) as a function of charge and mass of the particle plus dimensionless parameter characterizing the modification of Debye model implied by the fact that dust particles are not electrically closed systems. Authors give a long list of life-like properties possessed by the helical structures.

2. Helical structures are generated spontaneously and possess negative charges. The repulsion of the helical structures transforms to attraction at some critical distance interval due to the fact that the large electrostatic self energy depends on the distance between helices and this makes possible double helices (authors speak about over-screening in the formal model). Similar mechanism might work also in the case of ordinary DNA double helices whose stability is poorly understood since also in this case the large negative charge could be preserved by continual feed of charge.

3. The twist angle of the helix makes bifurcations as a function of radius of helix and the values of twist angle could define the letters of genetic code. Also a mechanism for how the twist angle is communicated to neighboring helix is proposed. Also dust vortices are observed and might be those which one can occasionally observe during hot summer days.

4. Authors do not mention magnetic fields but my guess is that the helical structures reflect directly the geometry of the helical magnetic flux tubes, and that dark electron pairs with large Planck constant at these tubes might be the quantal aspect of the system. These currents might relate closely to the plasma current, which charges the dust particles. Also DNA, which is insulator, is known to be able to act as conductor, and here the free electron pairs associated with aromatic rings having $\hbar = n \times hbar_0$, $n = 5$ or 6, could make conduction possible since their Compton size would be n-fold.

5.2.2 Elephant trunks in astrophysics

TGD Universe is fractal and this means that the visible structures are formed around magnetic flux quanta containing dark matter with large hbar appear in all length scales and have geometric patterns reflecting the exact discrete symmetries of dark matter acting as rotational symmetries of the field body and at the level of visible matter giving rise to broken symmetries typical for molecular structures. The helical structures found from the rings of some planets could be one example of fractal life.

For some time ago I learned about "elephant trunks" found by Hubble (I am grateful for Miika Väisälä telling about the trunks and for giving references to the papers about the finding). They appear in very wide range of length scales: at least from 1000 au to 1 pc. They are found in close connection with molecular clouds and HII regions excite by one or more young hot stars (a "metabolic connection" with the above mentioned unidentified bands and lines and PAHs present only if there is also UV source present does not look like a bad guess). In general the trunks are

Another important finding supporting TGD view about Universe which might be seen as a fractally scaled variant of above helices. pointing like fingers to the hot stars. Here is abstract of the paper by P. Carlquist, G. F. Gahm, and H. Kristen [32].

Using the 2.6 m Nordic Optical Telescope we have observed a large number of elephant trunks in several regions. Here, we present a small selection of this material consisting of a few large, well-developed trunks, and some smaller ones. We find that: (i) the well-developed trunks are made up of dark filaments and knots which show evidence of twisted structures, (ii) the trunks are connected with essentially two filamentary legs running in V-shape, and (iii) all trunks have the maximum extinction in their heads. We advance a theory of twisted elephant trunks which is based on the presence of magnetic flux ropes in molecular clouds where hot OB stars are formed. If the rope contains a local condensation it may adopt a V-shape as the region around the hot stars expands. If, in addition, the magnetic field in the rope is sufficiently twisted, the rope may form a double helix at the apex of the V. The double helix is identified with the twisted elephant trunks. In order to illustrate the mechanisms behind the double helix we have constructed a mechanical analogy model of the magnetic flux rope in which the rope has been replaced by a bundle of elastic strings loaded by a weight. Experiments with the model clearly show that part of the bundle will transform into a double helix when the twist of the bundle is sufficiently large. We have also worked out a simple theoretical model of a mass-loaded magnetic flux rope. Numerical calculations show that a double helix will indeed form when the twist of the rope exceeds a certain critical limit. Numerical model calculations are applied to both the analogy model experiments and one of the well-developed elephant trunks. On the basis of our model we also suggest a new interpretation of the so called EGGs.

The double helix mechanism is quite general, and should be active also in other suitable environments. One such environment may be the shell of supernova remnants. Another example is the expanding bubble outlined by the North Celestial Pole Loop.

For fractally thinking physicist consisting mostly of dark matter with large Planck constant this does not leave many options: life and even intelligent life is everywhere and in all length scales. This provides also a new view about Fermi paradox: see the article [16], which summarizes also the essentials of TGD, TGD based ontology, and TGD based quantum biology.

5.3 Universal metabolic quanta

Universal energy quanta might have rather interesting implications. For instance, irradiation of cells could provide a direct metabolic mechanism when the normal metabolic machinery fails. The universal metabolic quanta should have also played a key role during pre-biotic evolution when chemical storage mechanism were absent or primitive so that energy metabolism relied on direct absorption of photons.

5.3.1 Direct support for universal metabolic energy quanta

There is direct support for the notion of universal energy quanta. The first support comes from the effect of low-power laser light on living matter. More than 30 years ago a method known with various names such as low-power laser therapy, biostimulation, or photobiomodulation emerged [60] and has now a wide range of applications. The treatment can apply both non-coherent (light emitting diodes) or coherent (laser light). In the case of of non-coherent light the method applies thin structures with thickness smaller than coherence length of light so that there is no difference between non-coherent and laser light. Laser light applies to situation when both the thickness of the surface layer and structure itself in range 1 mm- 1 cm and shorter than coherence length. Often the irradiation is applied to wounds and sites of injuries, acupuncture points, and muscle trigger points. The method involves several parameters such as wavelength in the range 400-900 nm (IR and near IR light), output power (10 100 mW), continuous wave and pulsed operation modes, and pulse parameters.

1. What is known?

The article of Karu [60] gives a good summary about what is known.

1. The action spectrum characterizes the maxima of the biological response as a function of wavelength. Action spectrum is essentially universal. For near IR and IR light the maxima of spectra are at 620, 680, 760, 820-830 nm. The spectrum continues also to visible light [60] but I do not have access these data.

2. The action can induce both physiological and morphological changes in non-pigmental cells via absorption in mitochondria. HeNe laser ($\lambda = 632.8$ nm) can alter the firing pattern of nerves and can mimic the effect of peripheral stimulation of a behavioral reflex.

2. Biochemical approach

In [60] the biochemical approach to the situation is discussed.

1. In standard biochemistry based approach the natural hypothesis is that the maxima correspond to some molecular absorption lines and the task is to identify the photo acceptor. The primary acceptor in IR-to red spectral region is believed to be the terminal enzyme of the respiratory chain cytochrome c oxidase located in mitochondrion but this is just an assumption.In the violet-to-blue spectral region flavoproteins (e.g. NADHdehydrogenace in the beginning of respiratory chain) are among the photo acceptors as terminal oxidases. It is known that also non-mitochondrial enhancement of cellular metabolism exist, which does not fit well with the vision about mitochondria as power plants of cell. It is believed that electronic excitation occurs and somehow leads to the biological effect.

2. The natural assumption in biochemistry framework is that the stimulation increases the effectiveness of cellular metabolism by making the utilization of oxygen more effective. The effect of the light would occur at the control level and induce secondary reactions (cellular signaling cascades or photo signal transduction and amplification) affecting eventually the gene expression.

3. Three different regulation pathways have been suggested [60]. Since small changes in ATP level can alter cellular metabolism significantly, the obvious idea is that photoacceptor controls the level of intracellular ATP. In starving cells this looks especially attractive hypothesis. In many cases however the role of redox homeostasis is however believed to be more important than that of ATP. The second and third pathways would indeed affect cellular redox potential shifting it to more oxidized direction. The mechanism of regulation is however not understood. Hence one can say that there is no experimental proof or disproof for the standard approach.

3. TGD inspired approach

In TGD framework the first guess is that irradiation pumps directly metabolic energy to the system by kicking particles to smaller space-time sheets. This kind of direct energy feed would be natural when the cell is starving or injured so that its control mechanisms responsible for the utilization of oxygen are not working properly. For Bose-Einstein condensate of photons this effect would be especially strong being proportional to N^2 rather than N, where N is photon number. The effect would also appear coherently in a region whose size is dictated by coherence length when the target is thick enough.

There is a simple killer test for the proposal. The predicted energies are universal in the approximation that the interactions of protons (or electrons) kicked to the smaller space-time sheets with other particles can be neglected. The precise scale of metabolic energy quanta can be fixed by using the nominal value of metabolic energy quantum .5 eV in case of proton. This predicts the following spectrum of universal energy quanta for proton and electron

$$\begin{aligned}
&\Delta E_{k,n}(p) = E_0(k,p) \times (1-2^{-n}) \ , \\
&E_0(k,p) = E_0(137,p)2^{137-k} \simeq 2^{137-k} \times .5 \ \ eV \ \ .
\end{aligned}$$

$$\begin{aligned}
&\Delta E_{k,n}(e) = E_0(k,e) \times (1-2^{-n}) \ , \\
&E_0(k,e) = \frac{m_p}{2^{11}m_e} E_0(137,p)2^{148-k} \simeq 2^{148-k} \times .4 \ \ eV \ \ .
\end{aligned}$$

k characterizes the p-adic length scale and the transition corresponds to the kicking of charged particle from space-time sheet having $k_1 = k+n$ to $k = n$.

The shortest wavelength 630 nm is rather close to the wavelength of HeNe laser and corresponds to red light with $E_0 = 2.00$ eV. Thus one would have $k = 135$ in the case of proton which corresponds to roughly one of atomic radius for ordinary value of $\hbar$. For electron one would have $k = 150$ which corresponds to $L(151)/\sqrt{2}$: $L(151) = 10$ nm corresponds to cell membrane thickness. The following table gives the energies of photons for action spectrum and predicted values in the case of proton, which provides a better fit to the data.

n	2	3	4	5
λ/nm	825	760	680	620
E_{exp}/eV	1.50	1.63	1.82	2.00
E_{pred}/eV	1.50	1.75	1.88	1.94
E_{pred}/E_{exp}	1.00	1.07	1.02	0.97

(9)

The largest error is 7 per cent and occurs for $n = 3$ transition. Other errors are below 3 per cent. Note that also in experiments of Gariaev [50, 51] laser light consisting of 2 eV photons was used: in this case the induced radio wave photons - possibly dark photons with energy 2 eV - had positive effect on growth of potatoes.

5.3.2 Possible explanation for the effect of IR light on brain

The exposure of brain to IR light at wavelength of 1072 nm is known to improve learning performance and give kick start to cognitive function [59]. The simplest explanation is that this light reloads the metabolic energy batteries of neurons by kicking electrons or protons or their Cooper pairs to larger space-time sheets. The wavelength in question is roughly one half of the wavelength associated with metabolic energy quantum with average energy .5 eV (2480 μm) assignable to the dropping of proton to a very large space-time sheet from k=137 space-time sheet or of electron from k=137+11= 148 space-time sheet. This if the electron and proton are approximated to be free particles. Energy band is in question since both the particles can have additional interaction energy.

For the kicking of electron from very large space-time sheet to $k = 147$ space-time sheet the wave length would be below 1240 nm which is more than 10 per cent longer than 1072 nm. This would suggest that the final state electron is in excited state. The surplus energy is consistent with the width about 100 nm for the UIBs. This identification - if correct - would support the view that metabolic energy quanta are universal and have preceded the evolution of the biochemical machinery associated with metabolism and that the loading of metabolic energy batteries at the fundamental level correspond to the kicking of charged particles to smaller space-time sheets.

5.3.3 Connection between laser induced healing, acupuncture, and association of DC currents with the healing of wounds

The findings of Robert Becker (the book "Electromagnetism and Life" by Becker and Marino can be found from web [61]) meant a breakthrough in the development of bioelectromagnetics. One aspect of bioelectromagnetic phenomena was the discovery of Becker that DC currents and voltages play a pivotal role in various regeneration processes. Why this is the case is still poorly understood and Becker's book is a treasure trove for anyone ready to challenge existing dogmas. The general vision guiding Becker can be summarized by a citation from the introduction of the book.

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

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

1. Observations relating to CNS

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

1. CNS and the rest of perineural tissue (tissue surrounding neurons including also glial cells) form a dipole like structure with neural system in positive potential and perineural tissue in

negative potential. There is also an electric field along neuron in the direction of nerve pulse propagation (dendrites correspond to - and axon to +) (note that motor nerves and sensory nerves form a closed loop). Also microtubules within axon carry electric field and these fields are probably closely related by the many-sheeted variants of Gauss's and Faraday's laws implying that voltages along two different space-time sheets in contact at two points are same in a static situation.

2. A longitudinal potential along front to back in brain with frontal lobes in negative potential with respect to occipital lobes and with magnitude of few mV was discovered. The strength of the electric field correlates with the level of consciousness. As the potential becomes weaker and changes sign, consciousness is lost. Libet and Gerard observed traveling waves of potentials across the cortical layers (with speeds of about 6 m/s: TGD inspired model of nerve pulse predicts this kind of waves [M2]). Propagating potentials were discovered also in glial cells. The interpretation was in terms of electrical currents.

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

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

2. Observations relating to regeneration

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

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

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

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

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

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

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

7. The experiments of Becker and collaborators support the identification of the charge carriers of DC currents responsible for the formation of large negative potential of stump as electrons. The test was based on the different temperature dependence of electronic and protonic conductivities. Electronic conductivity increases with temperature and protonic conductivity decreases and an increase was observed. In TGD based model also super-conducting charge carriers are possible and this finding does not tell anything about them.

3. A TGD based model for the situation

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

1. Becker assigns to the system involved with DC currents an effective semiconductor property. Could the effective semiconductor property be due the fact that the transfer of charge carriers to a smaller space-time sheet by first accelerating them in electric field is analogous to the transfer of electrons between conduction bands in semiconductor junction? If so, semiconductor property would be a direct signature of the realization of the metabolic energy quanta as zero point kinetic energies.

2. Supra currents flowing along magnetic flux tubes would make possible dissipation free loading of metabolic energy batteries. This even when oscillating Josephson currents are in question since the transformation to ohmic currents in semiconductor junction makes possible energy transfer only during second half of oscillation period. Could this be a completely general mechanism applying in various states of regeneration process. This might be the case. In quantal situation the metabolic energy quanta have very precise values as indeed required. For ohmic currents at room temperature the thermal energies are considerably higher than those corresponding to the voltage involved so that they seem to be excluded. The temperature at magnetic flux tubes should be however lower than the physiological temperature by a factor of order 10^{-2} at least for the voltage of -1 mV. This would suggest high T_c superconductivity is only effective at the magnetic flux tubes involved. The finding that nerve pulse involves a slight cooling of the axonal membrane proposed in the TGD based model of nerve pulse [M2] to be caused by a convective cooling due the return flow of ionic Josephson currents would conform with this picture.

3. What meridians are and what kind of currents flow along them? Could these currents be supra currents making possible dissipation-free energy transfer in the healthy situation? Does the negative potential of order -1 mV make possible flow of protonic supra currents and loading of metabolic batteries by kicking protons to smaller space-time sheets? Could electronic supra currents in opposite direct induce similar loading of metabolic batteries? Could these tow miniature metabolisms realize control signals (protons) and feedback (electrons)?

The model answering these questions relies on following picture. Consider first meridians.

1. The direct feed of metabolic energy as universal metabolic currencies realized as a transfer of charge carriers to smaller space-time sheets is assumed to underly all the phenomena involving healing aspect. Meridian system would make possible a lossless metabolic energy feed - transfer of "Chi" - besides the transfer of chemically stored energy via blood flow. The metabolic energy currencies involved are very small as compared to .5 eV and might be responsible only for "turning control knobs". The correlation of the level of consciousness with the overall strength of DC electric fields would reduce to the level of remote metabolic energy transfer.

2. The model should explain why meridians have not been observed. Dark currents along magnetic flux tubes are ideal for the energy transfer. If the length of the superconducting "wire" is long in the scale defined by the appropriate quantum scale proportional to $\hbar$, classical picture makes sense and charge carriers can be said to accelerate and gain energy ZeV. For

large values of $\hbar$ an oscillating Josephson current would be in question. The semiconductor like structure at the end of meridian -possibly realized in terms of pair of space-time sheets with different sizes- makes possible a net transfer of metabolic energy even in this case as pulses at each half period of oscillation. The transfer of energy with minimal dissipation would thus explain why semiconductor like property is needed and why acupuncture points have high value of conductivity. The identification of meridians as invisible magnetic flux tubes carrying dark matter would explain the failure to observe them: one further direct demonstration for the presence of dark matter in biological systems.

3. In the case of regeneration process NEJs would be accompanied by a scaled down version of meridian with magnetic flux tubes mediating the electronic Josephson current during blastema generation and protonic supra current during the regeneration proper. Space-time sheets of proton *resp.* electron correspond to k_p and $k_e = k_p + 11$. In a static situation many-sheeted Gauss law in static situation would guarantee that voltages over NJE are same.

4. One can of course worry about the smallness of electrostatic energies ZeV as compared to the thermal energy. Zero point kinetic energy could correspond also to the magnetic energy of the charged particle. For sufficiently large values of Planck constant magnetic energy scale is higher than the thermal energy and the function of voltage could be only to drive the charged particles along the flux tubes to the target: and perhaps act as a control knob with electrostatic energy compensating for the small lacking energy. Suppose for definiteness magnetic field strength of $B = .2$ Gauss explaining the effects of ELF em fields on brain and appearing in the model of EEG. Assume that charged particle is in minimum energy state with cyclotron quantum number $n = 1$ and spin direction giving negative interaction energy between spin and magnetic field so that the energy is $(g-2)\hbar eB/2m_p$. Assume that the favored values of hbar correspond to number theoretically simple ones expressible as a product of distinct Fermat primes and power of 2. In the case of proton with $g \simeq 2.7927$ the standard metabolic energy quantum $E_0 = .5$ eV would require roughly $\hbar/\hbar_0 = 17 \times 2^{34}$. For electron $g - 2 \simeq \alpha/\pi \simeq .002328$ gives $\hbar/\hbar_0 = 5 \times 17 \times 2^{30}$.

Consider next NEJs and semiconductor like behavior and charging of metabolic batteries.

1. Since NEJ seems resembles cell membrane in some respects, the wisdom gained from the model of cell membrane and DNA as tqc can be used. The model for nerve pulse and the model for DNA as topological quantum computer suggest that dark ionic currents flowing along magnetic flux tubes characterized by a large value of Planck constant are involved with both meridians and NJEs and might even dominate. Magnetic flux tubes act as Josephson junctions generating oscillatory supra currents of ions and electrons. For large values of $\hbar$ also meridians are short in the relevant dark length scale and act as Josephson junctions carrying oscillatory Josephson currents.

2. The findings of Becker suggest that acu points correspond to sensory receptors which are normally in a negative potential. The model for the effects of laser light favors (but only slightly) the assumption that in a healthy situation it is protons arriving along magnetic flux tubes which are kicked to the smaller space-time sheets and that negative charge density at acu point attracts protons to the acu point. Electrons could of course flow in reverse direction along their own magnetic flux tubes and be kicked to the smaller space-time sheets at the positive end of the circuit. In the case of brain, protonic end would correspond to the frontal lobes and electronic end to the occipital lobes. This kind of structure could appear as fractally scaled variants. For instance, glial cells and neurons could form this kind of pair with neurons in negative potential and glial cells in positive potential as suggested by the fact that neuronal damage generates positive local potential.

3. Classically the charge carriers would gain energy $E = ZeV$ as they travel along the magnetic flux tube to NJE. If this energy is higher than the metabolic energy quantum involved, it allows the transfer of charge carrier to a smaller space-time sheet so that metabolic resources are regenerated. Several metabolic quanta could be involved and the value of $V(t)$ would determine, which quantum is activated. The reduction of the V below critical value would lead to a starvation of the cell or at least to the failure of control signals to "turn the control knob". This should relate to various symptoms like pain at acupuncture points. In a situation requiring acupuncture the voltage along flux tubes would be so small that the transfer of protons to the smaller space-time sheets becomes impossible. As a consequence, the positive charge carriers would accumulate to the acu point and cause a further reduction of the voltage. Acupuncture needle would create a "wound" stimulating large positive potential and the situation would be very much like in regeneration process and de-differentiation induced by acupuncture could be understood.

Many questions remain to be answered.

1. What causes the de-differentiation of the cells? The mere charging of metabolic energy batteries perhaps? If so then the amount of metabolic energy- "chi"- possessed by cell would serve as a measure for the biological age of cell and meridian system feeding "chi" identified as dark metabolic energy would serve as a rejuvenating agent also with respect to gene expression. Or does the electric field define an external energy feed to a self-organizing system and create an electromagnetic environment similar to that prevailing during morphogenesis inducing a transition of cells to a dedifferentiated state? Or could DNA as tqc allow to understand the modification of gene expression as being due to the necessity to use tqc programs appropriate for regeneration? Or should cells and wounded body part be seen as intentional agents doing their best to survive rather than as passive parts of biochemical system?

2. Acupuncture and DC current generation are known to induce generation of endorphins. Do endorphins contribute to welfare by reducing the pain or do they give a conscious expression for the fact that situation has improved as a result of recharging of the metabolic energy batteries?

3. Could the continual charging of metabolic energy batteries by DC currents occur also in the case of cell membrane? The metabolic energy quantum would be around .07 eV in this case and correspond to p-adic length scale $k = 140$ for proton (the quantum is roughly a fraction 1/8 of the fundamental metabolic energy quantum .5 eV corresponding to $k = 137$).

5.3.4 Gene activation by electrostatic fields?

The basic question concerns the method of activation. The discovery of chemists Guido Ebner and Guido Schuerch [63, 64, 65] raises the hope that these ideas might be more than over-active imagination and their work also provides a concrete proposal for the activation mechanism. These findings are briefly described in the article of Hardmuth Mueller [65] who proposes quite different explanation for the strange findings. Ebner and Schuerch studied the effect of electrostatic fields on the growth and morphogenesis of various organisms. Germ, seeds, or eggs were placed between conducting plates creating an electric field in the range .5-2 kV/m: note that the Earth's electric field is in the range $.1 - 4$ kV/m and of the same order of magnitude.

The outcome was rather surprising and in the year 1989 their employer Ciba Geigy (now Novaris) applied for a patent "Method of enhanced fish breeding" [63] for what is called Ciba Geigy effect. The researchers describe how fishes (trouts) develop and grow much better, if their eggs have been conditioned in an electrostatic field. The researchers report [63, 64] that also the

morphology of the fishes was altered to what seems to represent an ancient evolutionary form: this was not mentioned in the patent.

The chemists founded their own Institute of Pharmaceutical Research near Basel, where Guido Ebner applied for another very detailed patent, which was never granted (it is not difficult to guess the reasons why!). In the patent he describes the effect of electrostatic fields on several life forms (cress, wheat, corn, fern, micro-organisms, bacteria) in their early stage of development. A clear change in the morphogenesis was observed. For instance, in one example fern had all sort of leaves in single plant apparently providing a series of snapshots about the evolution of the plant. The evolutionary age of the first leaf appeared to be about 300 million years whereas the last grown-up leaf looked close to its recent form.

If one takes these finding seriously, one must consider the possibility that the exposure to an electrostatic field can activate passive genes and change the gene expression so that older morphologies are expressed. The activation of not yet existing morphologies is probably more difficult since strong consistency conditions must be satisfied (activation of program requires activation of a proper hardware). This would suggest that genome is a kind of archive containing also older genomes even potential genomes or that topological quantum computer programs [L5] determine the morphology to certain extent and that external conditions such as electric field determine the self-organization patters characterizing these programs.

It is known that the developing embryo has an electric field along the head-tail axis and that this field plays an important role in the control of growth. These fields are much weaker than the fields used in the experiment. p-Adic length scale hierarchy however predicts an entire hierarchy of electric fields and living matter is indeed known to be full of electret structures. The strength of the electric field in some p-adic length scale related to DNA might somehow serve as the selector of the evolutionary age. The recapitulation of phylogeny during the ontogeny could mean a gradual shift of the activated part of the memone, perhaps assignable to tqc programs, and be controlled by the gradually evolving electric field strength.

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

5.3.5 Could UV photons have some metabolic role?

The correlation between UV photons and ERE brings in mind the vision that high temperature plasmoids are primitive life-forms possibly having universal metabolic energy quanta in UV range. One can imagine that the development of chemical energy storage mechanisms has made it possible to use visible light from Sun as a source of metabolic energy and get rid of UV quanta having disastrous biological effects. Ozone layer shields out most of UV light and also air absorbs the UV light below wavelength 200 nm, which justifies the term vacuum UV (VUV) for this range.

Δk	1	2	≥ 3	∞
$\Delta E(144, \Delta k)/eV$	4	6	≥ 7	8
λ/nm	310(UVB)	207(UVB)	≤ 177 (VUV)	155 (VUV)

Table 3. The lines corresponding to the dropping of electron from $k = 144$ space time sheet defining a candidate for UV light inducing generation of ERE in the interstellar dust.

From Table 3 one finds that $\Delta k > 2$ electronic transitions cascading to 8 eV (155 nm) by period doubling) belong to vacuum UV (VUV) absorbed by air. The lines 310 nm and 207 nm

corresponding to $\Delta k = 1$ and $\Delta k = 2$ could however define frequency windows since these lines need not correspond to any atomic or molecular electronic transitions.

In the solar photosphere the temperature is about 5800 K, roughly half of the minimum temperature 10^4 K needed to generate the UV radiation inducing ERE in interstellar dust. Solar corona however has temperature of about 10^6 K, which corresponds to a thermal energy of order 100 eV and the UV radiation from corona at above mentioned discrete frequencies resulting in dropping of electrons could serve as a metabolic energy source for pre-biotics in the interstellar space. This raises obvious questions. Should the stellar sources inducing ERE possess also corona? Could 4 eV and 6 eV UV photons from the solar corona serve as a source of metabolic energy for some primitive organisms like blue algae?

5.3.6 A simple model for the metabolism of plasmoids

Extended Red Emissions (EREs) are associated with the interstellar dust in presence of UV light with energies above 7.25 eV and source with temperature not below 10^4 K (maximum of wave length distribution of black body radiation corresponds to the energy 4.97 eV at this temperature). This suggests that plasmoids using UV photons as metabolic energy are involved.

1. Since the bond energies of molecules vary in few eV range and their formation typically liberates photons in UV range, the natural hypothesis is that the metabolic cycle is based on the formation of some molecule liberating UV photon kicking electron/proton to a smaller space-time sheet. UV photons from energy source would in turn induce dissociation of the molecule and thus drive the process. The process as a whole would involve several p-adic length scales and several metabolic currencies.

2. This situation is of course encountered also in the ordinary biology but with highly developed sharing of labor. Biosphere would burn hydrocarbons in animal cells with carbon dioxide as the eventual outcome. Carbon dioxide would in turn be used by plants to regenerate the hydrocarbons. Note that in the recent day technology the loop is open: hydrocarbons are burned but there is no process regenerating them: perhaps photons with large Planck constant might some day used to regenerate the fuel and give rise to "living" and perhaps tidier technology.

3. It is believed that complex organic molecules like amino-acids can form in the interstellar dust and the spontaneous formation of aminoacids is known to be possible in the interstellar ice under UV radiation. Hence at least N_2 and perhaps also CO can be expected to be present. The table below gives dissociation energies of some simple molecules.

Molecule	H_2	O_2	N_2	CO	NO
E_D/eV	4.48	5.08	7.37	11.11	5.2

   i) N_2 has bond energy 7.37 eV is slightly above the UV threshold 7.26 eV for ERE, which strongly suggests that N_2 is one of the molecules involved with the metabolism of interstellar plasmoids.

   ii) If ice is present then carbon monoxide CO would be an excellent candidate for a metabolic molecule since its bond energy is as high as 11.11 eV. The exceptionally large bond energy would naturally relate to the fact that carbon and oxygen are the key molecules of life.

5.3.7 Anomalous light phenomena as plasmoids

TGD suggests that anomalous light phenomena (ALPs, or light balls, or UFOs depending on one's tastes and assumptions) are identifiable as plasmoids behaving as primitive life forms. In

the conference held in Röros Björn Gitle-Hauge told about the determination of the spectrum of visible light emitted by some light balls observed in Hessdalen [25] ("Hessdalen phenomenon" is the term used).

1. The spectrum is a band in the interval 500-600 nm whereas the typical ERE [24] is concentrated in the interval 650-750 nm. The peak is in the interval 540-900 nm, the width of the band is also now 100 nm, and there are no sharp peaks. Therefore the interpretation as ERE can be considered.

2. Because Hessdalen is an old mining district, authors propose that the light ball could consist of burning dust containing some metals. Author proposes that the burning of Titanium and Scandium (encountered only in Scandinavia) might provide the energy for the light ball. Sc reacts vigorously with acids and air (burning in oxygen gives Sc_2O_3 as end product). Ti burns in oxygen and is the only element that burns in nitrogen. Ti is used in fireworks since it produces spectacular fires.

   Author notices that the emission lines of N^+, Al^{++}, *resp.* Sc^+ at 528.02 nm, 528.2 nm, *resp.* 528.576 nm might contribute to the band. This might be the case but the explanation of the band solely in terms of molecular transitions is not favored by its smoothness.

3. The bond energies of TiO and TiN are 6.9 eV and 5.23 eV so that the radiation resulting in their formation is in UV range and could provide part of the metabolic energy. I do not know about bond energy of Scandium oxide.

4. TiO_2 is known to catalyze photolysis in the presence of UV light [28, 27], which in turn is basic step in photosynthesis [26], the basic step of which in TGD Universe would be the kicking of electrons/protons to smaller space-time sheets. Therefore the UV photons liberated in the formation of molecules containing Ti could catalyze photosynthesis like process.

5.4 Life as a symbiosis of plasmoids and biological life

If evolution has discovered something it usually keeps it so that plasmoids and UV metabolism should be still there. This suggests that plasmoids are still in ionosphere. What could this mean? There also also other questions and I am grateful for Sampo Vesterinen for some of them. The key questions are perhaps the following ones. Do plasmoids and biological life forms live in symbiosis in some sense? If this is the case, what plasmoids can give to us and what we can give to plasmoids?

1. Magnetic bodies as quantum plasmoids and plasmoids in magnetosphere

One must make clear what one means with plasmoid. One can consider a plasma made of ordinary visible matter and also large $\hbar$ quantum plasma at magnetic bodies in a form of Bose-Einstein condensates of charged particles. The symbiosis of plasmoids and biomatter could correspond to the symbiosis of magnetic body and biological body.

One can imagine also the possibility that visible matter plasmoids and bio-matter are in symbiosis via the mediation of magnetic bodies. Note that DNA strands are negatively charged so that there is a resemblance with a plasma like state. One aspect of symbiosis would be that magnetic body would feed charged particles to DNA.

2. Some basic facts about magnetosphere

Magnetosphere would be a natural environment for plasmoid population. If one restricts plasmoids to to visible matter, then ionosphere, plasma sphere and plasma sheet are the most interesting objects of interest.

1. The temperature in the highest F layer of the ionosphere (extending from 150 km to 1500 km depending on source) is about 1200-1300 K: the photon energy is about .6-.65 eV at

the maximum wavelength of thermal distribution. Hence F layer plasmoids might receive metabolic energy in the form of .5 eV metabolic energy quanta via thermal photons. Self-organization occurs in transition layers and especially interesting is the transition region 85-300 km from mesosphere to ionosphere at which temperature increases 300 K to about 1200 K.

2. Inner magnetosphere is a toruslike structure whose extension varies between $4R_E$ (day side) and $8R_E$ (night side) and shielded from solar wind. In the inner magnetosphere the typical density is about 1 ion per cubic centimeter. Inner magnetosphere is bounded by a transition layer of thickness of $\sim R$ (magneto-pause). In this region the density of the ions drops rapidly.

   Inner magnetosphere contains plasma sphere whose radius varies in the range $2R_E - 4R_E$ at day side and $2R_E - 6R_E$ at night side. Plasma has a ionospheric origin. The density of the cold plasma consisting mainly of protons sphere varies in the range $10 - 10^3$ ions/cm^3, whereas the temperature is $\sim 5 \times 10^3$ K, which corresponds to metabolic energy quantum of .5 eV. Note however that the energy of photon at maximum of thermal distribution is about 2.5 eV which suggests 2 eV metabolic quantum.

   The cold, dense plasma of plasma sphere is frozen around magnetic flux lines which co-rotate with Earth. In TGD framework this means that flux tubes co-rotate and thus change shape. In the equitorial plane the density of the plasma sphere drops sharply down to ~ 1 ion/cm^3 at $r = 4R$. This transition region is known as a plasma pause. During magnetic storms the outer radius decreases since the pressure of the solar wind compresses the plasma sphere. The day-night variation of the shape of the plasma sphere is rather small. Within this region the magnetic field has in a reasonable approximation dipole shape with radiation belts forming an exception.

   The surface temperature of Sun is 6×10^3 K. This temperature is roughly half of the minimum temperature 10^4 K needed for EREs from interstellar dust [24]. This corresponds to photon energy of 3 eV at the maximum of thermal distribution and cannot induce dissociation of N_2 and other simple diatomic molecules. There is also solar corona but its temperature is about 10^6 K (10^2 eV) so that the flux of thermal photons at UV energies is very low.

   Taking seriously the finding that $T \geq 10^4$K for source is necessary for EREs, one might ask whether the plasmoids at the day side are able to receive enough metabolic energy from UV radiation of Sun. If course, there is is no need to assume that dissociation of N_2 molecules is key element in metabolic mechanism. The temperatures in both F layer and plasma sphere allow kicking of protons and electrons to smaller space-time sheets and this might save the situation. Hence metabolism is not a problem for the plasmoids except perhaps during night-time when the plasma cools down somewhat.

3. The plasma sheet [29, N1] at the night side of Earth dark is the most prominent feature of the outer magnetosphere. It has a thickness about Earth radius R_E and extends beyond Moon's orbit (with radius $10^3 R_E$). The average densities of charged particles are very low and same order of magnitude as in plasma sphere: about .4-2 per cm^3 for both protons and electrons and correlates with solar wind density.

   The temperature is very high: the thermal energy of electrons is in keV range and ionic temperatures are even higher. The high temperature is due to the leakage of matter from solar wind. Note that up to the distance $d \sim 10^2 R_E$ equator region of outer magnetosphere at the night side of Earth experiences a continual solar eclipse so that this region does not receive radiation energy from Sun: the high temperature of plasma sheet solves this metabolic problem.

The presence of keV photons would destroy molecules at plasma sheet and induce a high degree of ionization so that plasmoid life must be based on ions and electrons. The energy needed to kick an electron to an atomic space-time sheet is about keV from $m_e/m_p \sim 2^{-11}$: hence the dropping of electrons from atomic space-time sheets would be the natural metabolic mechanism for plasmoid life at plasma sheet.

One of the original motivations for the plasmoid hypothesis was the strange finding that plasma sheet at the equator at the dark side of Earth is highly self-organized structure and the velocity distributions of electrons present patterns like "flowers", "eyes", "butterflies" [N1].

3. What plasmoids could give to us and what we could give to plasmoids?

An attractive general motivation for the symbiosis would be that magnetic bodies would give us ability to think and we would give them ability to sense.

1. The model of cognitive representations relies on the intersections of magnetic bodies with corresponding p-adic space-time sheets possessing literally infinite size in the real sense. The larger the magnetic body, the better the representations. Magnetic bodies could thus provide us with cognitive representations and an interesting question is whether and how this relates to the strange self-organization patterns at plasma sheet.

2. We could provide for magnetic bodies sensory input and serve as their motor instruments. These magnetic bodies might be also associated with plasma sheet and the plasmoids of ionosphere and plasma sphere and could also use plasmoids of visible matter as sensory receptors and perhaps even primitive motor instruments.

One can imagine also more concrete motivations for the symbiosis.

1. Plasmoids in the day-side ionosphere could shield biosphere from UV light by "eating" the incoming UV light. Magnetic bodies could also feed negative electronic charge from the plasmoids of magnetosphere to DNA double strands.

2. Plasmoids are not in a need of metabolic energy unless it happens that the temperature in F layer cools too much during night time from $T \sim 0.12$ eV. One might imagine that plasmoids suck metabolic energy from the biosphere during sleep (say brains which remain active): this would be a possible explanation for why we sleep. One can even imagine that during sleep magnetospheric collective levels of consciousness take command and life forms in the biosphere entangle to form kind of stereo consciousness providing a collective view what is to be human, member of species, or a part of biosphere.

4. About the interpretation of bio-photons?

Also the wave lengths of bio-photons are in the range of visible photons. Their spectrum is claimed to be featureless, which would suggest that identification in terms of photons resulting in dropping of electrons and protons to larger space-time sheets might not make sense. The variation of the geometric shape of space-time sheets, the possibility of surplus energy, and the clustering of the transition lines around the lower end of wave length spectrum might however give rise to effectively featureless spectrum.

Suppose that bio-photons correspond to superposition of ERE bands and thus reflect the presence of UV energy feed. Unless biological body is not able to generate the needed UV photons, they must arrive from Sun. Bio-photons or their dark counterparts with much longer wavelengths

could indeed live at the flux quanta of the magnetic bodies and observed visible bio-photons could represent some kind of leakage.

5. Gariaev's experiments

Gariaev's experiments [50] involved the irradiation of DNA using visible laser light with photon energy 1.9595 eV. The irradiation induced emission of radio waves with same polarization with frequencies above kHz. Radio waves induced growth of potatoes. A possible interpretation is that 2 eV photons kicked electrons to a smaller space-time sheet and thus gave metabolic energy to DNA. The radio waves possibly resulting in the dropping of electrons back to the larger space-time sheets could have consisted of dark photons with same or smaller energy and could have been used as a metabolic energy by the potatoes. That the dropping can occur to several space-time sheets would explain why several radio wave frequencies were observed. The prediction would be sum of period doubling spectra discussed earlier since sequences of droppings are possible. The radio-wave signal would result from the de-coherence of dark radio-wave photons to a bundle of ordinary radio-wave photons.

6. Earth's interior as a living system?

For years ago I developed in detail the working hypothesis that entire magnetosphere is a living system. Even Earth's interior (and also solar surface) could contain plasmoid life [N4, N1]. The temperature below the mantle of Earth does not differ too much from the surface temperature of Sun and metabolic energy could come from the radioactive decays from the interior of Earth. There would be UV shielding by Earth: UV light has energies above 3.1 eV whereas the temperature at the mantle-core boundary is 4300 K which corresponds to energy 2.2 eV energy at the maximum of thermal distribution. Metabolic energy quantum of 2 eV would be highly suggestive and might be directly used to kick protons and electrons to smaller space-time sheet.

The metabolism would not probably involve energy quantum of .5 eV. Magnetic flux tubes could also mediate metabolic energy from the biosphere and possibly also ionosphere and the plasmoid life in question could be at an evolutionary level not tolerating UV light and involve molecules in essential manner.

6 Exotic color and electro-weak interactions

The finding of a correct interpretation of long ranged electro-weak and color gauge fields predicted by classical TGD has been the basic stumbling block for the development of the understanding of TGD Universe and it took about 27 years before the time was ripe to see that TGD predicts entire fractal hierarchy of scaled down copies of standard model physics so that TGD Universe can be seen as a kind of inversion of Mandelbrot fractal for which each new bird eye of view reveals new structures assignable to higher levels in the hierarchy of consciousness.

6.1 Long range classical weak and color gauge fields as correlates for dark massless weak bosons

Long ranged electro-weak gauge fields are unavoidably present when the dimension D of the CP_2 projection of the space-time sheet is larger than 2. Classical color gauge fields are non-vanishing for all non-vacuum extremals. This poses deep interpretational problems. If ordinary quarks and leptons are assumed to carry weak charges feeded to larger space-time sheets within electro-weak length scale, large hadronic, nuclear, and atomic parity breaking effects, large contributions of the classical Z^0 force to Rutherford scattering, and strong isotopic effects, are expected. If weak charges are screened within electro-weak length scale, the question about the interpretation of long ranged classical weak fields remains.

6.1.1 Various interpretations for the long ranged classical electro-weak fields

During years I have discussed several solutions to the problems listed above.

Option I: The trivial solution of the constraints is that Z^0 charges are neutralized at electro-weak length scale. The problem is that this option leaves open the interpretation of classical long ranged electro-weak gauge fields unavoidably present in all length scales when the dimension for the CP_2 projection of the space-time surface satisfies $D > 2$.

Option II: Second option involves several variants but the basic assumption is that nuclei or even quarks feed their Z^0 charges to a space-time sheet with size of order neutrino Compton length. The large parity breaking effects in hadronic, atomic, and nuclear length scales is not the only difficulty. The scattering of electrons, neutrons and protons in the classical long range Z^0 force contributes to the Rutherford cross section and it is very difficult to see how neutrino screening could make these effects small enough. Strong isotopic effects in condensed matter due to the classical Z^0 interaction energy are expected. It is far from clear whether all these constraints can be satisfied by any assumptions about the structure of topological condensate.

Option III: During 2005 (27 years after the birth of TGD!) third option solving the problems emerged based on the progress in the understanding of the basic mathematics behind TGD.

In ordinary phase the Z^0 charges of elementary particles are indeed neutralized in intermediate boson length scale so that the problems related to the parity breaking, the large contributions of classical Z^0 force to Rutherford scattering, and large isotopic effects in condensed matter, trivialize.

Classical electro-weak gauge fields in macroscopic length scales are identified as space-time correlates for the gauge fields created by dark matter, which corresponds to a macroscopically quantum coherent phase for which elementary particles possess complex conformal weights such that the net conformal weight of the system is real.

In this phase $U(2)_{ew}$ symmetry is not broken below the scaled up weak scale except for fermions so that gauge bosons are massless below this length scale whereas fermion masses are essentially the same as for ordinary matter. By charge screening gauge bosons look massive in length scales much longer than the relevant p-adic length scale. The large parity breaking effects in living matter (chiral selection for bio-molecules) support the view that dark matter is what makes living matter living.

6.1.2 Classical color gauge fields

Classical long ranged color gauge fields always present for non-vacuum extremals are interpreted as space-time correlates of gluon fields associated with dark copies of hadron physics. It seems that this picture is indeed what TGD predicts. A very special feature of classical color fields is that the holonomy group is Abelian. This follows directly from the expression $g^A_{\alpha\beta} \propto H^A J_{\alpha\beta}$ of induced gluon fields in terms of Hamiltonians H^A of color isometries and induced Kähler form $J_{\alpha\beta}$. This means that classical color magnetic and electric fluxes reduce to the analogs of ordinary magnetic fluxes appearing in the construction of configuration space geometry [B2, B3].

By a local color rotation the color field can be rotated to a fixed direction so that genuinely Abelian field would be in question apart from the possible presence of gauge singularities making impossible a global selection of color direction. These singularities could be present since Kähler form defines a magnetic monopole field. An interesting question inspired by quantum classical correspondence is what the Abelian holonomy tells about the sources of color gauge fields and color confinement.

For instance, could Abelian holonomy mean that colored gluons (and presumably also other colored particles) do not propagate in the p-adic length scale considered? Color neutral gluons would propagate but since also their sources must be color neutral, they should have vanishing net color electric fluxes. This form of confinement would allow those states of color multiplets which have vanishing color charges and obviously symmetry breaking down to $U(1) \times U(1)$ would be in

question. This would serve as a signal for monopole confinement which would not exclude higher multipoles for the Abelian color fields. This kind of fields appear in the the TGD based model for nuclei as nuclear strings bound together by color flux tubes [F8]. In the sequel the model for nuclear color force is briefly discussed in order to give an idea about how the dark color forces might act also in longer length scales.

6.2 Dark color force as a space-time correlate for the strong nuclear force?

Color confinement suggests a basic application of the basic criteria for the transition to large $\hbar$ phase. The obvious guess is that valence quarks are dark [J6, F10]. Dark matter phase for quarks does not change the lowest order classical strong interaction cross sections but reduces dramatically higher order perturbative corrections and resolves the problems created by the large value of QCD coupling strength in the hadronic phase.

The challenge is to understand the strong binding solely in terms of dark QCD with large value of $\hbar$ reducing color coupling strength of valence quarks to $v_0 \simeq 2^{-11}$. The best manner to introduce the basic ideas is as a series of not so frequently asked questions and answers.

6.2.1 Rubber band model of strong nuclear force as starting point

The first question is what is the vision for nuclear strong interaction that one can start from. The sticky toffee model of Chris Illert [71] is based on the paradox created by the fact alpha particles can tunnel from the nucleus but that the reversal of this process in nuclear collisions does not occur. Illert proposes a classical model for the tunnelling of alpha particles from nucleus based on dynamical electromagnetic charge. Illert is forced to assume that virtual pions inside nuclei have considerably larger size than predicted by QCD and the model. Strikingly, the model favors fractional alpha particle charges at the nuclear surface. The TGD based interpretation would be based on the identification of the rubber bands of Illert as long color bonds having exotic light quark and anti-quark at their ends and connecting escaping alpha particle to the mother nucleus. The challenge is to give meaning to the attribute "exotic".

6.2.2 How the darkness of valence quarks can be consistent with the known sizes of nuclei?

The assumption about darkness of valence quarks in the sense of of large $\hbar$ ($\hbar_s = \hbar/v_0$) is very natural if one takes the basic criterion for darkness seriously. The obvious question is how the dark color force can bind the nucleons to nuclei of ordinary size if the strength of color force is v_0 and color sizes of valence quarks are about $L(129)$?

It seems also obvious that $L(107)$ in some sense defines the size for nucleons, and somehow this should be consistent with scaled up size $L(k_{eff} = 129)$ implied by the valence quarks with large $\hbar$. The proposal of [J6, F10] inspired by RHIC findings [66] is that valence quarks are dark in the sense of having large value of $\hbar$ and thus correspond to $k_{eff} = 129$ whereas sea quarks correspond to ordinary value for $\hbar$ and give rise to the QCD size $\sim L(107)$ of nucleon.

If one assumes that the typical distances between sea quark space-time sheets of nucleons is obtained by scaling down the size scale of valence quarks, the size scale of nuclei comes out correctly.

6.2.3 Valence quarks and exotic quarks cannot be identical

The hypothesis is that nucleons contain or there are associated with them pairs of exotic quarks and flux tubes of color field bodies of size $\sim L(129)$ connecting the exotic quark and anti-quark in

separate nuclei. Nucleons would be structures with the size of ordinary nucleus formed as densely packed structures of size $L(129)$ identifiable as the size of color magnetic body.

The masses of exotic quarks must be however small so that they must differ from valence quarks. The simplest possibility is that exotic quarks are not dark but p-adically scaled down versions of sea quarks with ordinary value of $\hbar$ having $k = 127$ so that masses are scaled down by a factor 2^{-10}.

Energetic considerations favor the option that exotic quarks associate with nucleons via the $k_{eff} = 111$ space-time sheets containing nucleons and dark quarks. Encouragingly, the assumption that nucleons topologically condense at the weak $k_{eff} = 111$ space-time sheet of size $L(111) \simeq 10^{-14}$ m of exotic quarks predicts essentially correctly the mass number of the highest known super-massive nucleus. Neutron halos are outside this radius and can be understood in terms color Coulombic binding by dark gluons. Tetraneutron can be identified as alpha particle containing two negatively charged color bonds.

6.2.4 What determines the binding energy per nucleon?

The binding energies per nucleon for $A \geq 4$ to not vary too much from 7 MeV but the lighter nuclei have anomalously small binding energies. The color bond defined by a color magnetic flux tube of length $\sim L(k = 127)$ or $\sim L(k_{eff} = 129)$ connecting exotic quark and anti-quark in separate nucleons with scaled down masses $m_q(dark) \sim xm_q$, with $x = 2^{-10}$ for option for $k = 127$, is a good candidate in this respect. Color magnetic spin-spin interaction would give the dominant contribution to the interaction energy as in the case of hadrons. This interaction energy is expected to depend on exotic quark pair only. The large zero point kinetic energy of light nuclei topologically condensed at $k_{eff} = 111$ space-time sheet having possible identification as the dark variant of $k = 89$ weak space-time sheet explains why the binding energies of D and ^3He are anomalously small.

6.2.5 What can one assume about the color bonds?

Can one allow only quark anti-quark type color bonds? Can one allow the bonds to be also electromagnetically charged as the earlier model for tetra-neutron suggests (tetra-neutron would be alpha particle containing two negatively charged color bonds so that the problems with the Fermi statistics are circumvented). Can one apply Fermi statistics simultaneously to exotic quarks and anti-quarks and dark valence quarks?

Option I: Assume that exotic and dark valence quarks are identical in the sense of Fermi statistics. This assumption sounds somewhat non-convincing but is favored by p-adic mass calculations supporting the view that the p-adic mass scale of hadronic quarks can vary. If this hypothesis holds true at least effectively, very few color bonds from a given nucleon are allowed by statistics and there are good reasons to argue that nucleons are arranged to highly tangled string like structures filling nuclear volume with two nucleons being connected by color bonds having of length of order $L(129)$. The organization into closed strings is also favored by the conservation of magnetic flux.

The notion of nuclear string is strongly supported by the resulting model explaining the nuclear binding energies per nucleon. It is essential that nucleons form what might be called nuclear strings rather than more general tangles. Attractive p-p and n-n bonds must correspond to colored ρ_0 type bonds with spin one and attractive p-n type bonds to color singlet pion type bonds. The quantitative estimates for the spin-spin interaction energy of the lightest nuclei lead to more precise estimates for the lengths of color bonds. The resulting net color quantum numbers must be compensated by dark gluon condensate, the existence of which is suggested by RHIC experiments [66]. This option is strongly favored by the estimate of nuclear binding energies.

Option II: If Fermi statistics is not assumed to apply in the proposed manner, then color magnetic flux tubes bonds between any pair of nucleons are possible. The identification of color

isospin as strong isospin still effective removes color degree of freedom. As many as 8 color tubes can leave the nucleus if exotic quarks and anti-quarks are in the same orbital state and a cubic lattice like structure would become possible. This picture would be consistent with the idea that in ordinary field theory all particle pairs contribute to the interaction energy. The large scale of the magnetic flux tubes would suggest that the contributions cannot depend much on particle pair. The behavior of the binding energies favors strongly the idea of nuclear string and reduces this option to the first one.

6.2.6 What is the origin of strong force and strong isospin?

Here the answer is motivated by the geometry of CP_2 allowing to identify the holonomy group of electro-weak spinor connection as U(2) subgroup of color group. Strong isospin group SU(2) is identified as subgroup of isotropy group U(2) for space-time surfaces in a sub-theory defined by $M^4 \times S^2$, S^2 a homologically non-trivial geodesic sphere of CP_2 and second factor of $U(1) \times U(1)$ subgroup of the holonomies for the induced Abelian gauge fields corresponds to strong isospin component I_3. The extremely tight correlations between various classical fields lead to the hypothesis that the strong isospin identifiable as color isospin I_3 of exotic quarks at the ends of color bonds attached to a given nucleon is identical with the weak isospin of the nucleon. Note that this does not require that exotic and valence quarks are identical particles in the sense of Fermi statistics.

Does the model explain the strong spin orbit coupling ($L \cdot S$ force)? This force can be identified as an effect due to the motion of fermion string containing the effectively color charged nucleons in the color magnetic field $v \times E$ induced by the motion of string in the color electric field at the dark $k = 107$ space-time sheet.

6.2.7 How the phenomenological shell model with harmonic oscillator potential emerges?

Nucleus can be seen as a collection of of long color magnetic flux tubes glued to nucleons with the mediation of exotic quarks and anti-quarks. If nuclei form closed string, as one expects in the case of Fermi statistics constraint, also this string defines a closed string or possibly a collection of linked and knotted closed strings. If Fermi statistics constraint is not applied, the nuclear strings form a more complex knotted and linked tangle. The stringy space-time sheets would be the color magnetic flux tubes connecting exotic quarks belonging to different nucleons.

The color bonds between the nucleons are indeed strings connecting them and the averaged interaction between neighboring nucleons in the nuclear string gives in the lowest order approximation 3-D harmonic oscillator potential although strings have $D = 2$ transversal degrees of freedom. Even in the case that nucleons for nuclear strings and thus have only two bonds to neighbors the average force around equilibrium position is expected to be a harmonic force in a good approximation. The nuclear wave functions fix the restrictions of stringy wave functionals to the positions of nucleons at the nuclear strings. Using M-theory language, nucleons would represent branes connected by color magnetic flux tubes representing strings whose ends co-move with branes.

6.2.8 Which nuclei are the most stable ones and what is the origin of magic numbers?

$P = N$ closed strings correspond to energy minima and their deformations obtained by adding or subtracting nucleons in general correspond to smaller binding energy per nucleon. Thus the observed strong correlation between P and N finds a natural explanation unlike in the harmonic oscillator model. For large values of A the generation of dark gluon condensate and corresponding color Coulombic binding energy favors the surplus of neutrons and the generation of neutron halos. The model explains also the spectrum of light nuclei, in particular the absence of pp, nn, ppp, and nnn nuclei.

In the standard framework spin-orbit coupling explains the magic nuclei and color Coulombic force gives rise to this kind of force in the same manner as in atomic physics context. Besides the standard magic numbers there are also non-standard ones (such as $Z, N = 6, 12$) if the maximum of binding energy is taken as a definition of magic, there are also other magic numbers than the standard ones. Hence can consider also alternative explanations for magic numbers. The geometric view about nucleus suggests that the five Platonic regular solids might defined favor nuclear configurations and it indeed turns that they explain non-standard magic numbers for light nuclei.

New magic nuclei might be obtained by linking strings representing doubly magic nuclei. An entire hierarchy of linkings becomes possible and could explain the new magic numbers 14, 16, 30, 32 discovered for neutrons [67]. Linking of the nuclear strings could be rather stable by Pauli Exclusion Principle. For instance, ^{16}O would corresponds to linked ^4He and ^{12}C nuclei. Higher magic numbers $28, 50, ...$ allow partitions to sums of lower magic numbers which encourages to consider the geometric interpretation as linked nuclei. p-Adic length scale hypothesis in turn suggest the existence of magic numbers coming as powers of 2^3.

6.3 How brain could deduce the position and velocity of an object of perceptive field?

The basic degrees of freedom for mind like space-time sheets can be regarded as parameters specifying color quantization axes and spin quantization axis. The parameters characterizing the choices of the color quantization axes define 3+3-dimensional symplectic flag-manifold $F_3 = SU(3)/U(1) \times U(1)$ whereas the parameters fixing spin-quantization axes define two-dimensional flag-manifold $F_2 = SU(1)/U(1) = S^2$, which is identical to two-sphere and whose point characterizes some orientation vector. A mathematically attractive identification of the flag manifold F_3 is as a representation for the possible positions and velocities of an object of the perceptive field whereas F_2 could represent some orientation, say ear-to-ear orientation axis. This identification, if correct, provides additional support for the uniqueness of the choice of the imbedding space $H = M^4_+ \times CP_2$. Amazingly, the model of honeybee dance by Barbara Shipman leads to the identification of the flag manifold F_3 as a fundamental mathematical structure associated with the cognition of the honeybee.

Without a good physical justification this kind of identification is however ad hoc. Fortunately, the following argument makes it possible to understand why F_3 should code the position and the velocity of the objects of the perceptive field.

1. The time development by quantum self-organization is expected to lead to well defined asymptotic values of (P, Q) coordinates during each wake-up period of the mind like space-time sheet representing object of the perceptive field and in self-state.

2. The crucial observation is that classical em and Z^0 fields are accompanied by classical color fields in TGD. Color rotations rotate the color field in color space whereas induced Kähler form remains unchanged. Most importantly: classical em and Z^0 fields do not remain invariant under color rotations as they would remain in standard model. This leads to the idea that different (P, Q) values obtained by color rotations of cognitive and neuronal space-time sheets correspond to slightly different membrane potentials and that it is the dependence of the membrane potential on the position and velocity of the object of the perceptive field, which leads to (P, Q) coding.

3. An observation not directly related to (P, Q) coding is that classical em and color fields induce tiny color polarization at quark level leading to color polarization of nuclei: this color polarization could provide the quantum correlate for the color quale. The representation of

color in this manner however requires that (P, Q) are same for all neurons in the perceptive field so that the coding of positions and velocities and color are mutually exclusive. Positions and velocities and color are indeed represented by different regions of cortex.

4. Color rotation induces motion in F_3 rotating color quantization axes and leaving the induced Kähler field invariant so that absolute minima of Kähler action are mapped to absolute minima and zero modes are not changed. Classical Z^0 and em fields are however *not* invariant under color rotations. How classical em and Z^0 depend on Kähler form becomes clear from the the following formulas:

$$\begin{aligned} \gamma &= 3J - \frac{1}{2} sin^2\theta_W Z^0 \ , \\ Z^0 &= 2J + 4e^0 \wedge e^3 \ , \\ J &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) \ . \end{aligned} \tag{10}$$

Here J denotes Kähler form invariant under color rotations and e^k denote vierbein vectors of CP_2. $e^0 \wedge e^3$ denotes the part of Z^0, which is not invariant under color rotations. From these formulas it is evident that classical photon field is not in general invariant since it is a superposition of the induced Kähler field and classical Z^0 field and reduces to induced Kähler field only when the Weinberg angle vanishes: the physical value of the Weinberg angle is about $sin^2(\theta_W) = 1/4$. This means that various points (P, Q) of (3+3)-dimensional F_3 indeed correspond to different classical Z^0 fields and classical em fields.

5. There is however an important exception to this picture. If CP_2 projection belongs to geodesic sphere S^2, the field equations reduces to those for $X^4 \subset M^4 \times S^2$. For space-time sheets for which CP_2 projection is $r = \infty$ homologically non-trivial geodesic sphere of CP_2 one has

$$\gamma = (\frac{3}{4} - \frac{sin^2(\theta_W)}{2})Z^0 \simeq \frac{5Z^0}{8}$$

as the explicit study of $r = \infty$ geodesic sphere shows (see the appendix of the book). The induced W fields vanish in this case and they vanish also for all geodesic spheres obtained by $SU(3)$ rotation. There are excellent reasons to believe that also the relationship between Z^0 and γ is $SU(3)$ invariant so that there would be no mixing between em and Z^0 fields. For homologically trivial geodesic spheres γ and Z^0 vanish and only W fields are non-vanishing. This kind of MEs would naturally correspond to W MEs.

For $D > 2$-dimensional CP_2 projection the situation changes. MEs have always 2-D CP_2 projection field equations and field equations are satisfied without assuming that CP_2 projection is a geodesic sphere and in this case one can hope of getting mixing of γ and Z^0 also in this case perhaps characterizable in terms of the value of the Weinberg angle. Also W fields can be present in this case.

6. Assuming that the values of (P, Q) coordinates are the same for the neuronal group representing an object of the perceptive field and the mind like space-time sheet associated with it (this could be forced by the wormhole contacts), (P, Q) coding for the positions and velocities for the objects of the perceptive field follows if these observables are coded into the properties of the classical Z^0 field associated with the neuronal membrane. This seems plausible since a change of the classical Z^0 field implies a change of the classical em field if the induced Kähler field remains invariant (as is natural). Thus the problem of understanding (P, Q) coding for

position and velocity reduces to the problem of understanding why the position and velocity should affect some natural em field associated with cell membrane. Obviously membrane resting potential is an excellent candidate for this em field.

7. The dependence of the value of the membrane resting potential for the representation of an object of the perceptive field on the the position and velocity of the object is natural. For instance, it is advantageous for the neurons representing object near to the observer to be nearer to the criticality for firing. Thus the membrane potential must be reduced by a suitable color rotation and effective code position of the object to Q coordinates. Also, when the object moves towards/away from the observer, the resting potential should be reduced/increased and this means that velocity is coded to P value (note that there is infinite number of canonical coordinates at use). From these correlations it is quite plausible that (P, Q) coding could be a result of natural selection. Of course, the coding of position and velocity to (P, Q) values need not be one-to-one. For instance, simple organisms are sensitive for velocity only and some organisms experience world as 2-dimensional.

6.4 Boolean mind and dark neutrinos

The unavoidable prediction of classical TGD is the presence of long ranged classical electro-weak fields in all long scales and the only reasonable interpretation is in terms of dark matter hierarchy suggesting the existence of light copies of ordinary elementary particles in all length scales coupling to ordinary matter only via gravitation. Even more, the length scale range 10 nm-2.5 μm contains four Gaussian Mersennes possibly assignable to fractally scaled down copies of electro-weak physics.

One ends up with a rather concrete quantum model for Boolean mind based on neutrinos by

1. combining the concept of association sequence as 3-surface which is a union of space-like 3-surface with time-like separations with the fermionic realization of Boolean algebra ;

2. requiring that fermionic states exist only in a finite time interval defined by the duration of the mind-like space-time sheets;

3. assuming that time-like entanglement is possible for many-fermion states. A rigorous definition of time like entanglement in terms of so called Connes tensor product is discussed in [C6]. According to this identification time-like entanglement at given level of cognitive hierarchy represents the S-matrix at lower level of hierarchy as entanglement coefficients so that states at higher level can represent dynamics at the lower level. This highly restricted form of entanglement is in accordance with the very restricted failure of classical determinism.

Ordinary fermions cannot reside on mind-like space-time sheets unless they are created as pairs with vanishing total quantum numbers (in particular energy!) such that the quantum numbers of fermion and anti-fermion at space-time sheets of opposite time orientation compensate each other. Dark neutrinos are however exceptional since their interaction energy [F8, F10] is negative and it is possible to create pairs with vanishing net energy such that both members are at space-time sheet of positive time orientation.

Dark neutrinos are an ideal tool of cognition since they do not couple to electromagnetic interactions and, having couplings only to dark weak bosons, dissipate extremely weakly. The creation of cognitive neutrino pairs by the splitting of a wormhole contact connecting two space-time sheets is indeed possible and provides a possible realization for thinking system. Wormhole contact itself can be regarded as a neutrino-antineutrino pair bound assignable to the causal horizons of the wormhole contact. Logical statement and its negation correspond naturally to Fock sates of dark antineutrinos (resp. dark neutrinos).

Quantum classical correspondence suggests that it is localization in zero modes, in fact the conscious selection between degenerate absolute minima of Kähler action, which selects beween various configurations of the classical Z^0 field. If the pattern of cognitive neutrino pairs is fixed by the classical Z^0 field, the premises and conclusions of the logical deductions would be represented in terms of cognitive neutrinos. This assumption is also in accordance with the hypothesis that the exponent of the Kähler action provides a measure for the cognitive resources of 3-surface defined as the number of degenerate absolute minima of Kähler action associated with the 3-surface [H7].

From this it is still a long way to precise models and one can make only educated guesses.

1. Cognitive neutrino pairs could reside in the defect regions of neutrino super conductor which is super-conductor of type I having complicated stripe like defect regions near criticality. TGD based model for the interaction of dark neutrinos with condensed matter predicts that the thickness of the defect regions is of order 10^{-8} meters. Hence cell membranes are excellent candidates for the defect regions. The model for the generation of cognitive neutrino pairs as zero energy states favors this option very strongly.

2. Also chromosomes (having same thickness as cell membranes) could be identified as defect regions of dark neutrino super conductor. Very simple model for the abstraction process as a hierarchy of Boolean statements about Boolean statements about... starting from two basic statements explains the basic numbers of the genetic code (see the chapter [H7]). It is difficult to believe that this could be mere accident. Cognitive neutrino pairs indeed allow to construct a model of a many-sheeted DNA realizing gene level Boolean mind and possibly explaining the mystery of introns [39].

Of course, conscious Boolean mind at gene level need not have anything to do with *our* logical mind, and probably does not. If it has, new forms of gene expression are necessary. The model for abstraction process however predicts entire hierarchy of "genetic codes", and the level next to the level realizing genetic code might correspond to what might be called memetic code realized in terms of the cognitive neutrino pairs associated with the cell membrane in accordance with the option 1) and leads up to a concrete model for memetic code relating temporal sequences of cognitive neutrino pairs associated with axons to cognitive experiences [L1].

7 The relationship between p-adic and real physics

p-Adic physics as physics of cognition and intentionality are the most exotic new physics involved with TGD and only heuristic ideas about the relationship of real and p-adic physics exist. The interpretation of the p-adic as physics of cognition and the vision about reduction of physics to rational physics continuable algebraically to various extensions of rationals and p-adic number fields is an attractive general framework allowing to understand how p-adic fractality could emerge in real physics. In this section it will be found that this vision provides a concrete tool in principle allowing to construct global solutions of field equations by reducing long length scale real physics to short length scale p-adic physics. Also p-adic length scale hypothesis can be understood and the notion of multi-p p-fractality can be formulated in precise sense in this framework. This vision leads also to a concrete quantum model for how intentions are transformed to actions and the S-matrix for the process has the same general form as the ordinary S-matrix.

7.1 p-Adic physics and the construction of solutions of field equations

The number theoretic vision about physics relies on the idea that physics or, rather what we can know about it, is basically rational number based. One interpretation would be that space-time surfaces, the induced spinors at space-time surfaces, configuration space spinor fields, S-matrix,

etc..., can be obtained by algebraically continuing their values in a discrete subset of rational variant of the geometric structure considered to appropriate completion of rationals (real or p-adic). The existence of the algebraic continuation poses very strong additional constraints on physics but has not provided any practical means to solve quantum TGD.

In the following it is however demonstrated that this view leads to a very powerful iterative method of constructing global solutions of classical field equations from local data and at the same time gives justification for the notion of p-adic fractality, which has provided very successful approach not only to elementary particle physics but also physics at longer scales. The basic idea is that mere p-adic continuity and smoothness imply fractal long range correlations between rational points which are very close p-adically but far from each other in the real sense and vice versa.

7.1.1 The emergence of a rational cutoff

For a given p-adic continuation only a subset of rational points is acceptable since the simultaneous requirements of real and p-adic continuity can be satisfied only if one introduces ultraviolet cutoff length scale. This means that the distances between subset of rational points fixing the dynamics of the quantities involved are above some cutoff length scale, which is expected to depend on the p-adic number field R_p as well as a particular solution of field equations. The continued quantities coincide only in this subset of rationals but not in shorter length scales.

The presence of the rational cutoff implies that the dynamics at short scales becomes effectively discrete. Reality is however not discrete: discreteness and rationality only characterize the inherent limitations of our knowledge about reality. This conforms with the fact that our numerical calculations are always discrete and involve finite set of points.

The intersection points of various p-adic continuations with real space-time surface should code for all actual information that a particular p-adic physics can give about real physics in classical sense. There are reasons to believe that real space-time sheets are in the general case characterized by integers n decomposing into products of powers of primes p_i. One can expect that for p_i-adic continuations the sets of intersection points are especially large and that these p-adic space-time surfaces can be said to provide a good discrete cognitive mimicry of the real space-time surface.

Adelic formula represents real number as product of inverse of its p-adic norms. This raises the hope that taken together these intersections could allow to determine the real surface and thus classical physics to a high degree. This idea generalizes to quantum context too.

The actual construction of the algebraic continuation from a subset of rational points is of course something which cannot be done in practice and this is not even necessary since much more elegant approach is possible.

7.1.2 Hierarchy of algebraic physics

One of the basic hypothesis of quantum TGD is that it is possible to define exponent of Kähler action in terms of fermionic determinants associated with the modified Dirac operator derivable from a Dirac action related super-symmetrically to the Kähler action.

If this is true, a very elegant manner to define hierarchy of physics in various algebraic extensions of rational numbers and p-adic numbers becomes possible. The observation is that the continuation to various p-adic numbers fields and their extensions for the fermionic determinant can be simply done by allowing only the eigenvalues which belong to the extension of rationals involved and solve field equations for the resulting Kähler function. Hence a hierarchy of fermionic determinants results. The value of the dynamical Planck constant characterizes in this approach the scale factor of the M^4 metric in various number theoretical variants of the imbedding space $H = M^4 \times CP_2$ glued together along subsets of rational points of H. The values of $\hbar$ are determined from the requirement of quantum criticality [C6] meaning that Kähler coupling strength is analogous to critical temperature.

In this approach there is no need to restrict the imbedding space points to the algebraic extension of rationals and to try to formulate the counterparts of field equations in these discrete imbedding spaces.

7.1.3 p-Adic short range physics codes for long range real physics and vice versa

One should be able to construct global solutions of field equations numerically or by engineering them from the large repertoire of known exact solutions [D1]. This challenge looks formidable since the field equations are extremely non-linear and the failure of the strict non-determinism seems to make even in principle the construction of global solutions impossible as a boundary value problem or initial value problem.

The hope is that short distance physics might somehow code for long distance physics. If this kind of coding is possible at all, p-adicity should be crucial for achieving it. This suggests that one must articulate the question more precisely by characterizing what we mean with the phrases "short distance" and "long distance". The notion of short distance in p-adic physics is completely different from that in real physics, where rationals very close to each other can be arbitrary far away in the real sense, and vice versa. Could it be that in the statement "Short length scale physics codes for long length scale physics" the attribute "short"/"long" could refer to p-adic/real norm, real/p-adic norm, or both depending on the situation?

The point is that rational imbedding space points very near to each other in the real sense are in general at arbitrarily large distances in p-adic sense and vice versa. This observation leads to an elegant method of constructing solutions of field equations.

1. Select a rational point of the imbedding space and solve field equations in the real sense in an arbitrary small neighborhood U of this point. This can be done with an arbitrary accuracy by choosing U to be sufficiently small. It is possible to solve the linearized field equations or use a piece of an exact solution going through the point in question.

2. Select a subset of rational points in U and interpret them as points of p-adic imbedding space and space-time surface. In the p-adic sense these points are in general at arbitrary large distances from each and real continuity and smoothness alone imply p-adic long range correlations. Solve now p-adic field equations in p-adically small neighborhoods of these points. Again the accuracy can be arbitrarily high if the neighborhoods are choose small enough. The use of exact solutions of course allows to overcome the numerical restrictions.

3. Restrict the solutions in these small p-adic neighborhoods to rational points and interpret these points as real points having arbitrarily large distances. p-Adic smoothness and continuity alone imply fractal long range correlations between rational points which are arbitrary distant in the real sense. Return to 1) and continue the loop indefinitely.

In this manner one obtains even in numerical approach more and more small neighborhoods representing almost exact p-adic and real solutions and the process can be continued indefinitely.

Some comments about the construction are in order.

1. Essentially two different field equations are in question: real field equations fix the local behavior of the real solutions and p-adic field equations fix the long range behavior of real solutions. Real/p-adic global behavior is transformed to local p-adic/real behavior. This might be the deepest reason why for the hierarchy of p-adic physics.

2. The failure of the strict determinism for the dynamics dictated by Kähler action and p-adic non-determinism due to the existence of p-adic pseudo constants give good hopes that the construction indeed makes it possible to glue together the (not necessarily) small pieces of space-time surfaces inside which solutions are very precise or exact.

3. Although the full solution might be impossible to achieve, the predicted long range correlations implied by the p-adic fractality at the real space-time surface are a testable prediction for which p-adic mass calculations and applications of TGD to biology provide support.

4. It is also possible to generalize the procedure by changing the value of p at some rational points and in this manner construct real space-time sheets characterized by different p-adic primes.

5. One can consider also the possibility that several p-adic solutions are constructed at given rational point and the rational points associated with p-adic space-time sheets labelled by $p_1, ..., p_n$ belong to the real surface. This would mean that real surface would be multi-p p-adic fractal.

I have earlier suggested that even elementary particles are indeed characterized by integers and that only particles for which the integers have common prime factors interact by exchanging particles characterized by common prime factors. In particular, the primes $p = 2, 3, ..., 23$ would be common to the known elementary particles and appear in the expression of the gravitational constant. Multi-p p-fractality leads also to an explanation for the weakness of the gravitational constant. The construction recipe for the solutions would give a concrete meaning for these heuristic proposals.

This approach is not restricted to space-time dynamics but is expected to apply also at the level of say S-matrix and all mathematical object having physical relevance. For instance, p-adic four-momenta appear as parameters of S-matrix elements. p-Adic four-momenta very near to each other p-adically restricted to rational momenta define real momenta which are not close to each other and the mere p-adic continuity and smoothness imply fractal long range correlations in the real momentum space and vice versa.

7.1.4 p-Adic length scale hypothesis

Approximate p_1-adicity implies also approximate p_2-adicity of the space-time surface for primes $p \simeq p_1^k$. p-Adic length scale hypothesis indeed states that primes $p \simeq 2^k$ are favored and this might be due to simultaneous $p \simeq 2^k$- and 2-adicity. The long range fractal correlations in real space-time implied by 2-adicity would indeed resemble those implied by $p \simeq 2^k$ and both $p \simeq 2^k$-adic and 2-adic space-time sheets have larger number of common points with the real space-time sheet.

If the scaling factor λ of $\hbar$ appearing in the dark matter hierarchy is in good approximation $\lambda = 2^{11}$ also dark matter hierarchy comes into play in a resonant manner and dark space-time sheets at various levels of the hierarchy tend to have many intersection points with each other.

There is however a problem involved with the understanding of the origin of the p-adic length scale hypothesis if the correspondence via common rationals is assumed.

1. The mass calculations based on p-adic thermodynamics for Virasoro generator L_0 predict that mass squared is proportional to $1/p$ and Uncertainty Principle implies that L_p is proportional to $\sqrt{p}$ rather than p, which looks more natural if common rationals define the correspondence between real and p-adic physics.

2. It would seem that length $d_p \simeq pR$, R or order CP_2 length, in the induced space-time metric must correspond to a length $L_p \simeq \sqrt{p}R$ in M^4. This could be understood if space-like geodesic lines at real space-time sheet obeying effective p-adic topology are like orbits of a particle performing Brownian motion so that the space-like geodesic connecting points with M^4 distance r_{M^4} has a length $r_{X^4} \propto r_{M^4}^2$. Geodesic random walk with randomness associated with the motion in CP_2 degrees of freedom could be in question. The effective p-adic topology indeed induces a strong local wiggling in CP_2 degrees of freedom so that r_{X^4} increases and can depend non-linearly on r_{M^4}.

3. If the size of the space-time sheet associated with the particle has size $d_p \sim pR$ in the induced metric, the corresponding M^4 size would be about $L_p \propto \sqrt{p}R$ and p-adic length scale hypothesis results.

4. The strongly non-perturbative and chaotic behavior $r_{X^4} \propto r_{M^4}^2$ is assumed to continue only up to L_p. At longer length scales the space-time distance d_p associated with L_p becomes the unit of space-time distance and geodesic distance r_{X^4} is in a good approximation given by

$$r_{X^4} = \frac{r_{M^4}}{L_p} d_p \propto \sqrt{p} \times r_{M^4} \quad , \tag{11}$$

and is thus linear in M^4 distance r_{M^4}.

7.1.5 Does cognition automatically solve real field equations in long length scales?

In TGD inspired theory of consciousness p-adic space-time sheets are identified as space-time correlates of cognition. Therefore our thoughts would have literally infinite size in the real topology if p-adics and reals correspond to each other via common rationals (also other correspondence based on the separate canonical identification of integers m and n in $q = m/n$ with p-adic numbers).

The cognitive solution of field equations in very small p-adic region would solve field equations in real sense in a discrete point set in very long real length scales. This would allow to understand why the notions of Universe and infinity are a natural part of our conscious experience although our sensory input is about an infinitesimally small region in the scale of universe.

The idea about Universe performing mimicry at all possible levels is one of the basic ideas of TGD inspired theory of consciousness. Universe could indeed understand and represent the long length scale real dynamics using local p-adic physics. The challenge would be to make quantum jumps generating p-adic surfaces having large number of common points with the real space-time surface. We are used to call this activity theorizing and the progress of science towards smaller real length scales means progress towards longer length scales in p-adic sense. Also real physics can represent p-adic physics: written language and computer represent examples of this mimicry.

7.2 A more detailed view about how local p-adic physics codes for p-adic fractal long range correlations of the real physics

The vision described earlier gives only a rough heuristic view about how the local p-adic physics could code for the p-adic fractality of long range real physics. There are highly non-trivial details related to the treatment of M^4 and CP_2 coordinates and to the mapping of p-adic H-coordinates to their real counterparts and vice versa.

7.2.1 How real and p-adic space-time regions are glued together?

The first task is to visualize how real and p-adic space-time regions relate to each other. It is convenient to start with the extension of real axis to contain also p-adic points. For finite rationals $q = m/n$, m and n have finite power expansions in powers of p and one can always write $q = p^k \times r/s$ such that r and s are not divisible by p and thus have pinary expansion of in powers of p as $x = x_0 + \sum_1^N x_n p^n$, $x_i \in \{0, p\}$, $x_0 \neq 0$.

One can always express p-adic number as $x = p^n y$ where y has p-adic norm 1 and has expansion in non-negative powers of p. When x is rational but not integer the expansion contains infinite number of terms but is periodic. If the expansion is infinite and non-periodic, one can speak about *strictly p-adic* number having infinite value as a real number.

In the same manner real number x can be written as $x = p^n y$, where y is either rational or has infinite non-periodic expansion $y = r_0 + \sum_{n>0} r_n p^{-n}$ in negative powers of p. As a p-adic number y is infinite. In this case one can speak about strictly real numbers.

This gives a visual idea about what the solution of field equations locally in various number fields could mean and how these solutions are glued together along common rationals. In the following I shall be somewhat sloppy and treat the rational points of the imbedding space as if they were points of real axis in order to avoid clumsy formulas.

1. The p-adic variants of field equations can be solved in the strictly p-adic realm and by p-adic smoothness these solutions are well defined also in as subset of rational points. The strictly p-adic points in a neighborhood of a given rational point correspond as real points to infinitely distant points of M^4. The possibility of p-adic pseudo constants means that for rational points of M^4 having sufficiently large p-adic norm, the values of CP_2 coordinates or induced spinor fields can be chosen more or less freely.

2. One can solve the p-adic field equations in any p-adic neighborhood $U_n(q) = \{x = q + p^n y\}$ of a rational point q of M^4, where y has a unit p-adic norm and select the values of fields at different points q_1 and q_2 freely as long as the spheres $U_n(q_1)$ and $U_n(q_2)$ are disjoint (these spheres are either identical or disjoint by p-adic ultra-metricity).

   The points in the p-adic continuum part of these solutions are at an infinite distance from q in M^4. The points which are well-defined in real sense form a discrete subset of rational points of M^4. The p-adic space-time surface constructed in this manner defines a discrete fractal hierarchy of rational space-time points besides the original points inside the p-adic spheres. In real sense the rational points have finite distances and could belong to disjoint real space-time sheets. The failure of the strict non-determinism for the field equations in the real sense gives hopes for gluing these sheets partially together (say in particle reactions with particles represented as 3-surfaces).

3. All rational points q of the p-adic space-time sheet can be interpreted as real rational points and one can solve the field equations in the real sense in the neighborhoods $U_n(q) = \{x = q+p^n y\}$ corresponding to real numbers in the the range $p^n \leq x \leq p^{n+1}$. Real smoothness and continuity fix the solutions at finite rational points inside $U_n(q)$ and by the phenomenon of p-adic pseudo constants these values can be consistent with p-adic field equations. Obviously one can can continue the construction process indefinitely.

7.2.2 p-Adic scalings act only in M^4 degrees of freedom

p-Adic fractality suggests that finite real space-time sheets around points $x + p^n$, $x = 0$, are obtained as by just scaling of the M^4 coordinates having origin at $x = 0$ by p^n of the solution defined in a neighborhood of x and leaving CP_2 coordinates as such. The known extremals of Kähler action indeed allow M^4 scalings as dynamical symmetries.

One can understand why no scaling should appear in CP_2 degrees of freedom. CP_2 is complex projective space for which points can be regarded as complex planes and for these p-adic scalings act trivially. It is worth of emphasizing that here could lie a further deep number theoretic reason for why the space S in $H = M^4 \times S$ must be a projective space.

7.2.3 What p-adic fractality for real space-time surfaces really means?

The identification of p-adic and real M^4 coordinates of rational points as such is crucial for p-adic fractality. On the other hand, the identification rational real and p-adic CP_2 coordinates as such

would not be consistent with the idea that p-adic smoothness and continuity imply p-adic fractality manifested as long range correlations for real space-time sheets

The point is that p-adic fractality is not stable against small p-adic deformations of CP_2 coordinates as function of M^4 coordinates for solutions representable as maps $M^4 \to CP_2$. Indeed, if the rational valued p-adic CP_2 coordinates are mapped as such to real coordinates, the addition of large power p^n to CP_2 coordinate implies small modification in p-adic sense but large change in the real sense so that correlations of CP_2 at p-adically scaled M^4 points would be completely lost.

The situation changes if the map of p-adic CP_2 coordinates to real ones is continuous so that p-adically small deformations of the p-adic space-time points are mapped to small real deformations of the real space-time points.

1. Canonical identification $I : x = \sum x_n p^n \to \sum x_n p^{-n}$ satisfies continuity constraint but does not map rationals to rationals.

2. The modification of the canonical identification given by

$$I(q = p^k \times \frac{r}{s}) = p^k \times \frac{I(r)}{I(s)} \tag{12}$$

   is uniquely defined for rational points, maps rationals to rationals, has a symmetry under exchange of target and domain. This map reduces to a direct identification of rationals for $0 \leq r < p$ and $0 \leq s < p$.

3. The form of this map is not general coordinate invariant nor invariant under color isometries. The natural requirement is that the map should respect the symmetries of CP_2 maximally. Therefore the complex coordinates transforming linearly under U(2) subgroup of SU(3) defining the projective coordinates of CP_2 are a natural choice. The map in question would map the real components of complex coordinates to their p-adic variants and vice versa. The residual $U(2)$ symmetries correspond to rational unitary 2×2-matrices for which matrix elements are of form $U_{ij} = p^k r/s$, $r < p, s < p$. It would seem that these transformations must form a finite subgroup if they define a subgroup at all. In case of $U(1)$ Pythagorean phases define rational phases but sufficiently high powers fail to satisfy the conditions $r < p, s < p$. Also algebraic extensions of p-adic numbers can be considered.

4. The possibility of pseudo constant allows to modify canonical identification further so that it reduces to the direct identification of real and p-adic rationals if the highest powers of p in r and s ($q = p^n r/s$) are not higher than p^N. Write $x = \sum_{n \geq 0} x_n p^n = x^{N)} + p^{N+1} y$ with $x^{N)} = \sum_{n=0}^{N} x_n p^n$, $x_0 \neq 0$, $y_0 \neq 0$, and define $I_N(x) = x^{N)} + p^{N+1} I(y)$. For $q = p^n r/s$ define $I_N(q) = p^n I_N(r)/I_N(s)$. This map reduces to the direct identification of real and p-adic rationals for $y = 0$.

5. There is no need to introduce the imaginary unit explicitly. In case of spinors imaginary unit can be represented by the antisymmetric 2×2-matrix ϵ_{ij} satisfying $\epsilon_{12} = 1$. As a matter fact, the introduction of imaginary unit as number would lead to problems since for $p \ mod \ 4 = 3$ imaginary unit should be introduced as an algebraic extension and CP_2 in this sense would be an algebraic extension of RP_2. The fact that the algebraic extension of p-adic numbers by $\sqrt{-1}$ is equivalent with an extension introducing $\sqrt{p-1}$ supports the view that algebraic imaginary unit has nothing to do with the geometric imaginary unit defined by Kähler form of CP_2. For $p \ mod \ 4 = 1$ $\sqrt{-1}$ exists as a p-adic number but is infinite as a real number so that the notion of finite complex rational would not make sense.

7.2.4 Preferred CP_2 coordinates as a space-time correlate for the selection of quantization axis

Complex CP_2 coordinates are fixed only apart from the choice of the quantization directions of color isospin and hyper charge axis in SU(3) Lie algebra. Hence the selection of quantization axes seems to emerge at the level of the generalized space-time geometry as quantum classical correspondence indeed requires.

In a well-defined sense the choice of the quantization axis and a special coordinate system implies the breaking of color symmetry and general coordinate invariance. This breaking is induced by the presence of p-adic space-time sheets identified as correlates for cognition and intentionality. One could perhaps say that the cognition affects real physics via the imbedding space points shared by real and p-adic space-time sheets and that these common points define discrete coordinatization of the real space-time surface analogous to discretization resulting in any numerical computation.

7.2.5 Relationship between real and p-adic induced spinor fields

Besides imbedding space coordinates also induced spinor fields are fundamental variables in TGD. The free second quantized induced spinor fields define the fermionic oscillator operators in terms of which the gamma matrices giving rise to spinor structure of the "world of classical worlds" can be expressed.

p-Adic fractal long range correlations must hold true also for the induced spinor fields and they are in exactly the same role as CP_2 coordinates so that the variant of canonical identification mapping rationals to rationals should map the real and imaginary parts of of real induced spinor fields to their p-adic counterparts and vice versa at the rational space-time points common to p-adic and real space-time sheets.

7.2.6 Could quantum jumps transforming intentions to actions really occur?

The idea that intentional action corresponds to a quantum jump in which p-adic space-time sheet is transformed to a real one traversing through rational points common to p-adic and real space-time sheet is consistent with the conservation laws since the sign of the conserved inertial energy can be also negative in TGD framework and the density of inertial energy vanishes in cosmological length scales [D5]. Also the non-diagonal transitions $p_1 \to p_2$ are in principle possible and would correspond to intersections of p-adic space-time sheets having a common subset of rational points. Kind of phase transitions changing the character of intention or cognition would be in question.

1. Realization of intention as a scattering process

The first question concerns the interpretation of this process and possibility to find some familiar counterpart for it in quantum field theory framework. The general framework of quantum TGD suggests that the points common to real and p-adic space-time sheets could perhaps be regarded as arguments of an n-point function determining the transition amplitudes for p-adic to real transition or $p_1 \to p_2$-adic transitions. The scattering event transforming an p-adic surface (infinitely distant real surface in real M^4) to a real finite sized surface (infinitely distant p-adic surface in p-adic M^4) would be in question.

2. Could S-matrix for realizations of intentions have the same general form as the ordinary S-matrix?

One might hope that the realization of intention as a number theoretic scattering process could be characterized by an S-matrix, which one might hope of being unitary in some sense. These S-matrix elements could be interpreted at fundamental level as probability amplitudes between intentions to prepare a define initial state and the state resulting in the process.

Super-conformal invariance is a basic symmetry of quantum TGD which suggests that the S-matrix in question should be constructible in terms of n-point functions of a conformal field theory restricted to a subset of rational points shared by real and p-adic space-time surfaces or their causal determinants. According to the general vision discussed in [C1], the construction of n-point functions effectively reduces to that at 2-dimensional sections of light-like causal determinants of space-time surfaces identified as partonic space-time sheets.

The idea that physics in various number fields results by algebraic continuation of rational physics serves as a valuable guideline and suggests that the form of the S-matrices between different number fields (call them non-diagonal S-matrices) could be essentially the same as that of diagonal S-matrices. If this picture is correct then the basic differences to ordinary real S-matrix would be following.

1. Intentional action could transform p-adic space-time surface to a real one only if the exponent of Kähler function for both is rational valued (or belongs to algebraic extension of rationals).

2. The points appearing as arguments of n-point function associated with the non-diagonal S-matrix are a subset of rational points of imbedding space whereas in the real case, where the integration over these points is well defined, all values of arguments can be allowed. Thus the difference between ordinary S-matrix and more general S-matrices would be that a continuous Fourier transform of n-point function in space-time domain is not possible in the latter case. The inherent nature of cognition would be that it favors localization in the position space.

3. Objection and its resolution

Exponent of Kähler function is the key piece of the configuration space spinor field. There is a strong counter argument against the existence of the Kähler function in the p-adic context. The basic problem is that the definite integral defining the Kähler action is not p-adically well-defined except in the special cases when it can be done algebraically. Algebraic integration is however very tricky and numerically completely unstable.

The definition of the exponent of Kähler function in terms of Dirac determinants or, perhaps equivalently, as a result of normal ordering of the modified Dirac action for second quantized induced spinors might however lead to an elegant resolution of this problem. This approach is discussed in detail in [B4, D1]. The idea is that Dirac determinant can be defined as a product of eigenvalues of the modified Dirac operator and one ends up to a hierarchy of theories based on the restriction of the eigenvalues to various algebraic extensions of rationals identified as a hierarchy associated with corresponding algebraic extensions of p-adic numbers. This hierarchy corresponds to a hierarchy of theories (and also physics!) based on varying values of Kähler coupling constant and Planck constant. The elegance of this approach is that no discretization at space-time level would be needed: everything reduces to the generalized eigenvalue spectrum of the modified Dirac operator.

4. A more detailed view

Consider the proposed approach in more detail.

1. Fermionic oscillator operators are assigned with the generalized eigenvectors of the modified Dirac operator defined at the light-like causal determinants:

$$\begin{aligned} \Psi &= \sum_n \Psi_n b_n \ , \\ D\Psi_n &= \Gamma^\alpha D_\alpha \Psi_n = \lambda_n O \Psi_n \ , \ O \equiv n_\alpha \Gamma^\alpha \ . \end{aligned} \tag{13}$$

Here $\Gamma^\alpha = T^{\alpha k}\Gamma_k$ denote so called modified gamma matrices expressible in terms of the energy momentum current $T^{\alpha k}$ assignable to Kähler action [B4]. The replacement of the ordinary gamma matrices with modified ones is forced by the requirement that the super-symmetries of the modified Dirac action are consistent with the property of being an extremal of Kähler action. n_α is a light like vector assignable to the light-like causal determinant and $O = n_\alpha\Gamma^\alpha$ must be rational and have the same value at real and p-adic side at rational points. The integer n labels the eigenvalues λ_n of the modified Dirac operator, and b_n corresponds to the corresponding fermionic oscillator operator.

2. The condition that the p-adic and real variants Ψ if the Ψ are identical at common rational points of real and p-adic space-time surface (the same applies to 4-surfaces corresponding to different p-adic number fields) poses a strong constraint on the algebraic continuation from rationals to p-adics and gives hopes of deriving implications of this approach.

3. Ordinary fermionic anti-commutation relations do not refer specifically to any number field. Super Virasoro (anti-)commutation relations involve only rationals. This suggest that fermionic Fock space spanned by the oscillator operators b_n is universal and same for reals and p-adic numbers and can be regarded as rational. Same would apply to Super Virasoro representations. Also the possibility to interpret configuration space spinor fields as quantum superpositions of Boolean statements supports this kind of universality. This gives good hopes that the contribution of the inner produces between Fock states to the S-matrix elements are number field independent.

4. Dirac determinant can be defined as the product of the eigenvalues λ_n restricted to a given algebraic extension of rationals. The solutions of the modified Dirac equation correspond to vanishing eigen values and define zero modes generating conformal super-symmetries and are not of course included.

5. Only those operators b_n for which λ_n belongs to the algebraic extension of rationals in question are used to construct physical states for a given algebraic extension of rationals. This might mean an enormous simplification of the formalism in accordance with the fact that configuration space Clifford algebra corresponds as a von Neumann algebra to a hyper-finite factor of type II_1 for which finite truncations by definition allow excellent approximations [C6]. One can even ask whether this hierarchy of algebraic extensions of rationals could in fact define a hierarchy of finite-dimensional Clifford algebras. If so then the general theory of hyper-finite factors of type II_1 would provide an extremely powerful tool.

8 Exotic representations of super-canonical algebra

The unique feature of the Super Virasoro algebra is that it allows a fractal hierarchy of sub-algebras and one obtains hierarchy of exotic representations in p-adic sector. One must however assume that Super Virasoro gauge conditions allow arbitrary values of the super-canonical scaling quantum number L_0 is non-vanishing. $L_0 = 0$ condition would be replaced by $L_0 \ mod \ p^n = 0$ condition in the p-adic context so that conformal invariance would become approximate in p-adic sense. The alternative interpretation would be as fractality in the sense that scalings would leave the states almost invariant.

One could however argue that exotic Super Virasoro representations can make sense only in the purely p-adic sense and the assumption that mass values values $M^2 \propto p^n$, which are gigantic in real sense, can be mapped by the canonical identification to $M^2 \propto p^{-n}$ is highly counter intuitive and has no physical basis. Also in p-adic mass calculations the canonical identification is applied only to fix the real probabilities as canonical images of the p-adic probabilities. Essentially the

same predictions would result by using a real statistical ensemble defined by the real counterparts of the p-adic probabilities since the three lowest powers of p determine the outcome in an excellent approximation (that is only the states with $M^2 \propto n$, $n \in \{0,1,2\}$ are included).

The idea that the states $L_0 \ \ mod \ \ p^n = 0$ are light in some well-defined physical sense is however too beautiful to be given up immediately, and an analogy with condensed matter lattice systems comes in rescue. For a one-dimensional lattice with lattice constant a only a discrete sub-group of translations acts as symmetries and momentum cutoff emerges via the condition $p \equiv p + n\hbar/a$. Although the large momenta $p = n\hbar/a$ are still real, they correspond to the motion of the entire lattice.

By replacing the lattice obtained by translations with a lattice obtained by scalings one would obtain a highly analogous situation. More concretely, suppose that L_0 act as infinitesimal scaling of the imbedding space coordinates of the space-time surface. The action is almost trivial if the space-time surface has a fractal structure in the sense of being approximately invariant under the scaling of the points of M^4 by powers of p. Let a be a positive integer replacing e as the base of exponential so that a^{mL_0} defines an exponentiated scaling. The condition $a^{mL_0} \ \ mod \ \ p = 1$ states that the state remains invariant under this scaling and corresponds to the invariance of lattice state under translation by a multiple ma of the lattice vector. By Fermat's little theorem this condition is satisfied if one has $L_0 \ \ mod \ \ p^n = 0$.

One can consider also the 2-based exponential of L_0 giving $2^{mL_0} \ \ mod \ \ p = 0$. p-Adic length scale hypothesis in its most general form stating $p \simeq 2^m$, m a positive integer, provides an approximate solution to this condition. Note that the fractal lattice picture suggests that p-adic cognitive codons corresponds to octaves of the p-adic frequency $f(n,k) = \hbar/T(n,k)$. In the case of memetic code this would mean that the frequency range $10 - 10^3$ Hz dictated by the time scale 1 ms of nerve pulse activity would contain 6 octaves meaning an effective reduction to genetic code with 6 bits. The prediction would be that the frequencies 10,20,40,80,160,320,640 Hz are in a special role in neural dynamics.

The idea p-adic local dynamics codes for the p-adic fractality of the long length scale real dynamics indeed leads to this kind of picture and leads to a concrete quantum model for intentional action allowing even to show that the S-matrix for intention-to-action transitions has the same general form as the ordinary S-matrix [E1, H8].

8.1 Exotic p-adic representations as representations for which states are almost p-adic fractals

When the value of L_0 is power of p: $L_0 \propto p^n$, $n = 1, 2, ..$, the real counterpart of the scaling quantum number is extremely small since it is proportional to $1/p^n$ in this case. In particular, the scalings a^{L_0} are p-adically very near to identity transformation for any integer by Fermat's theorem. Fractals are invariant under scalings and since the states of exotic representations are in good approximation invariant under the group of scalings one could say that they are fractals modulo $O(1/p)$, perhaps resulting as asymptotic states of self-organization processes. One can also say that Virasoro conditions are satisfied to order $O(1/p)$ and that approximate conformal invariance is realized ($L_0 = 0$ condition would completely trivialize the super-canonical representations since mass squared operator is not involved now). Note that the subalgebra of super-canonical algebra with conformal weights proportional to p^m emerges naturally as an algebra replacing the entire super-conformal algebra.

One could sharpen the notion of approximate super-conformal representation. The failure of L_0 to annihilate the states means that L_{mp^n} can generate zero norm state only in order $O(p^n)$. Thus only the generators L_{-mp^n}, $m \geq 0$, but not L_{mp^n} can annihilate the physical states. Same would hold true also for the super generators and super-canonical generators. Also multi-p-adic exotic representations are possible since any integer $n = \prod_i p_i^{k_i}$ defines a sub-algebra spanned by

the generators for which conformal weights are proportional to n.

The representations of the conformal algebra with a non-vanishing central charge could be in question. The central charge term in the commutators of the conformal generators, being proportional to $(c/12)(n^3-n)$ (c is central charge) is of order $O(p^k)$ unless p divides 12 (,that is $p=2$ or $p=3$ holds true,) or p divides the denominator of c, which is in general rational number. The central extension term for the anti-commutator of the fermionic super-generators G_n and G_{-n} is $\frac{c}{12}(2n-1)(2n+1)$ and is *not* of order $O(p^k)$ for n multiple of p^k.

Semiclassical argument suggests that the lengths of MEs associated with these representations correspond to p-adic length scales and it turns out that corresponding fundamental frequencies correspond to important EEG frequencies in ELF frequency range. This encourages to think that the exotic representations of super-canonical algebra might of special interest from the point of view of cognition.

Also quaternion conformal representations allow similar phenomenon and in this case p-adic mass squared proportional to L_0 has extremely small real counterpart. The mass squared associated with the corresponding real states is however astrophysical and, in contrast to the original working hypothesis, it will be assumed that these states are not important for consciousness. There are however indications supporting the importance of these states in hadron physics: one could perhaps understand non-perturbative aspects of QCD in terms of exotic p-adic quaternion-conformal representations.

8.2 Mersenne primes and Gaussian Mersennes are special

8.2.1 Mersenne primes

One can also consider the milder requirement that the exponent $\lambda = 2^{\epsilon L_0}$ represents trivial scaling represented by unit in good approximation for some p-adic topology. Not surprisingly, this is the case for $L_0 = mp^k$ since by Fermat's theorem $a^p \ mod \ p = 1$ for any integer a, in particular $a = 2$. This is also the case for $L_0 = mk$ such that $2^k \ mod \ p = 1$ for p prime. This occurs if $2^k - 1$ is Mersenne prime: in this case one has $2^{L_0} = 1$ modulo p so that the sizes of the fractal sub-algebras are exponentially larger than the sizes of $L_0 \propto p^n$ algebras. Note that all scalings a^{L_0} are near to unity for $L_0 = p^n$ whereas now only $a = 2$ gives scalings near unity for Mersenne primes. Perhaps this extended fractality provides the fundamental explanation for the special importance of Mersenne primes.

In this case integrated scalings 2^{L_0} leave the states almost invariant so that even a stronger form of the breaking of the exact conformal invariance would be in question in the super-canonical case. The representation would be defined by the generators for which conformal weights are odd multiples of n ($M_n = 2^n - 1$) and L_{-kn}, $k > 0$ would generate zero norm states only in order $O(1/M_n)$.

Especially interesting is the hierarchy of primes defined by the so called Combinatorial Hierarchy resulting from TGD based model for abstraction process. The primes are given by $2, 3, 7 = 2^3 - 1, 127 = 2^7 - 1, 2^{127} - 1$,..: $L_0 = n \times 127$ would correspond to M_{127}-adicity crucial for the memetic code.

8.2.2 Gaussian Mersennes are also special

If one allows also Gaussian primes then the notion of Mersenne prime generalizes: Gaussian Mersennes are of form $(1 \pm i)^n - 1$. In this case one could replace the scaling operations by scaling combined with a twist of $\pi/4$ around some symmetry axis: $1 + i = \sqrt{2}exp(i\pi/4)$ and generalized p-adic fractality would mean that for certain values of n the exponentiated operation consisting of n basic operations would be very near to unity.

i) The integers k associated with the lowest Gaussian Mersennes are following: $2, 3, 5, 7, 11, 19, 29, 47, 73, 79, 113$. $k = 113$ corresponds to the p-adic length scale associated with the atomic nucleus and muon. Thus all known charged leptons, rather than only e and τ, as well as nuclear physics length scale, correspond to Mersenne primes in the generalized sense.

ii) The primes $k = 151, 157, 163, 167$ define perhaps the most fundamental biological length scales: $k = 151$ corresponds to the thickness of the cell membrane of about ten nanometers and $k = 167$ to cell size about 2.56 μm. This observation also suggests that cellular organisms have evolved to their present form through four basic evolutionary stages. This also encourages to think that $\sqrt{2}exp(i\pi/4)$ operation giving rise to logarithmic spirals abundant in living matter is fundamental dynamical symmetry in bio-matter.

Logarithmic spiral provides the simplest model for biological growth as a repetition of the basic operation $\sqrt{2}exp(i\pi/4)$. The naive interpretation would be that growth processes consist of $k = 151, 157, 163, 167$ steps involving scaling by $\sqrt{2}$. This however requires the strange looking assumption that growth starts from a structure of size of order CP_2 length. Perhaps this exotic growth process is associated with pair of MEs or magnetic flux tubes of opposite time orientation and energy emergenging CP_2 sized region in a mini big bang type process and that the resulting structure serves as a template for the biological growth.

iii) $k = 239, 241, 283, 353, 367, 379, 457$ associated with the next Gaussian Mersennes define astronomical length scales. $k = 239$ and $k = 241$ correspond to the p-adic time scales .55 ms and 1.1 ms: basic time scales associated with nerve pulse transmission are in question. $k = 283$ corresponds to the time scale of 38.6 min. An interesting question is whether this period could define a fundamental biological rhythm. The length scale $L(353)$ corresponds to about 2.6×10^6 light years, roughly the size scale of galaxies. The length scale $L(367) \simeq \times 3.3 \times 10^8$ light years is of same order of magnitude as the size scale of the large voids containing galaxies on their boundaries (note the analogy with cells). $T(379) \simeq 2.1 \times 10^{10}$ years corresponds to the lower bound for the order of the age of the Universe. $T(457) \sim 10^{22}$ years defines a completely superastronomical time and length scale.

8.2.3 Connection with the em realization of genetic code and Gaussian Mersennes?

The considerations above suggest that $\sqrt{2} \times exp(i\pi/4)$ might code for a fundamental logarithmic spiral growth step in some sense. The powers of the phase factor $exp(i\pi/4)$ define 8-element cyclic group which should be thus fundamental for 2-adic logarithmic spiral growth process in which the diagonal of square becomes the side of the next square rotated by $\pi/4$ with respect to original one.

Perhaps it is worth of noticing that for 3-bit Boolean algebra with one statement excluded the maximal Boolean algebra corresponds to 2 bits of information, and is naturally associated with the predecessor of the genetic code in the hierarchy of codes predicted by the TGD based model for abstraction process. In this case the counterpart of 64 DNA triplets code for 4 statements and the 4 DNA nucleotides themselves might correspond to these "basic truths".

Second point perhaps worth of noticing is that the model of electromagnetic realization of the genetic code discussed in [H8], which was inspired by the observations Cyril Smith [47] about the coding of arithmetic operations to the sequences of 7 binary electromagnetic pulses, led to a guess for a 7-bit binary code for binary arithmetic operations of type $f = f(f_1, f_2) = Xf_1OYf_2$ giving output frequency as a function of two input frequencies f_1 and f_2. O codes for the arithmetic operation proper represented by single bit and the eight operations X and Y acting on the operands are represented by 3 bits each. Depending on context, $O = 0/1$ represents either $+/-$ or $\times//$.

There are eight different operations X (Y), which suggests an interpretation in terms of 8-element cyclic group. Perhaps the coding of the growth process might be achieved by this kind of coding. Each DNA triplet would code this kind of elementary growth process whereas conjugate triplet would code its time reversal. MEs would read genes to sequences of pulses of light-like vacuum current generating hologram realized in terms of coherent photons in turn coding the

growth program and conjugate DNA would give rise to time reversed phase conjugate hologram coding for the time reversal of the growth step.

What remains to be understood is the meaning of the arithmetic operation in the growth process. The coding of growth process might reduce to coding of the growth of MEs and superconducting magnetic flux tubes. If the eight rotations are accompanied by scalings, then multiplication and division of two growth steps would make sense since also the inverse of growth step makes sense. What remains however mysterious why DNA triplets would code the growth steps in this manner. An alternative interpretation is that a growth process of binary structures in question and that arithmetic operation $\pm$ tells something about the second member of the binary structure. For instance, pairs of mind like space-time sheets might be in question (pairs of spiralling MEs with light-like boundaries or wormhole magnetic fields) and $\pm$ might tell whether the other space-time sheet has positive or negative time orientation.

8.3 The huge degeneracies of the exotic states make them ideal for representational purposes

For a given eigenvalue of L_0 there is degeneracy of states given essentially by the exponent of L_0. The states with $L_0 = O(p^n)$ have enormous degeneracy since the degeneracy of states increases exponentially as function of mass (this in fact leads to Hagedorn temperature). Huge ground state degeneracy is just what also spin glass analogy suggests and effective information storage and processing requires. The huge (really!) information processing potential suggests that these states correspond to an infinite hierarchy of life forms. Thus matter or 'flesh' would correspond to states of super-canonical algebra with $L_0 = 0$ whereas the 'spirit' would correspond to states with L_0 eigenvalue divisible by p^n, $n = 1, 2, ..,$ p prime and to states with $L_0 \propto n$, $2^n - 1$ Mersenne prime. The identification of mind like space-time sheets as MEs which allow these sub-Super Virasoro representations, means that this hypothesis is consistent with TGD inspired theory of consciousness.

Thus one can conclude that life forms would be characterized by integer triplets

$$(p, m, n), \quad p \ \text{prime} \ .$$

This is a rather far-reaching prediction effectively promising a resolution to the riddle of life as a quantum physical phenomenon and gives a hint about the predictive and explanatory powers of geometrization of physics using p-adic numbers.

The Super Virasoro representations in question are associated with the algebra of super-canonical transformations. There are two kinds of bosonic generators. The generators of first kind correspond to infinitesimal canonical transformations of $E^2 \times CP_2$ localized with respect to the light-like coordinate S_+ of the light-like projection of the light-like boundary of ME. The coordinate lines of $S_\pm$ correspond in geometric optics picture curved light rays. E^2 denotes $S_+ = constant$ (or $S_- = constant$) 2-surface and can be obviously chosen in several manners. If ME is glued along a space-like section to some matter like 4-surface then this section most naturally corresponds to $S_+ = constant$ section. A tempting assumption is that sensory experience could be determined by the properties of the quantum state in this section. The generators of second type correspond to the radial Virasoro algebra (functions of S_+ coordinate) localized with respect to CP_2 coordinates so that they act as CP_2-local radial deformations of the light-like boundary. Fermionic generators are in one-one correspondence with the bosonic generators and correspond to configuration space gamma matrices. In the case of future light cone boundary similar algebra generates the isometries of the configuration space of 3-surfaces [B2, B3].

As noticed super-canonical and super-conformal degrees of freedom do not contribute to mass squared unlike quaternion conformal degrees of freedom. This means an immense degeneracy of states with respect to energy broken only by the non-commutativity of Poincare algebra and

super-canonical and super-conformal algebras. It is not at all obvious whether one can assing this degeneracy to elementary particles or only with the light-like boundaries of MEs.

Any function of $E^2 \times CP_2$ coordinates and of the radial coordinate S_+ of the light-like boundary (that is function of the coordinates of light-cone boundary δM^4_+) defines Hamiltonian and thus configuration space isometry. It is convenient to assume that Hamiltonians correspond to CP_2 partial waves with well defined color quantum numbers. In the case of S^2 one could assume angular momentum eigenstates but this choice is not practical. Generalized Super Virasoro algebra acts as CP_2-local conformal symmetries of light-cone boundary which by its metric 2-dimensionality indeed allows infinite-group of conformal symmetries. The functions of $E^2 \times CP_2$ coordinate having no dependence on the light-like coordinate E_+ of the light-cone boundary define the Hamiltonians of canonical transformations of $E^2 \times CP_2$. The subset of Hamiltonians with vanishing color and angular momentum quantum numbers ((I_3, Y) and J_z) correspond to the zero modes in the proposed complexification of the configuration space tangent space [B2, B3]. The group of these canonical transformations divided by the Cartan group of $U(1) \times SU(3)$ defines infinite-dimensional flag-manifold parametrizing all possible choices of quantization axes.

Super generators are expressible in terms of fermionic oscillator operators carrying quantum numbers of quarks and leptons. The Super Virasoro representations differ from the standard representations used in superstring models in that super generators are not Hermitian $G_r^\dagger \neq G_{-r}$) and carry fermion number [C1]. In quaternion confromal case Super generators carry lepton number in the case of Ramond type representations and quark number in the case of Neveu-Schwartz type representations. Super-canonical representations are Ramond type representations. Both quaternion conformal and super canonical representations carry all possible quark/lepton numbers and thus spans what is very much like the Fock states of second quantized theory with configuration space degrees of freedom included as additional degrees of freedom and reflecting the fact that point like particles are replaces with 3-D surfaces.

8.4 Could one assign life-forms to the exotic Super-Virasoro representations?

8.4.1 First order life forms associated with elementary particles

Exotic representations are possible also in quaternion-conformal sector. In this case mass squared operator is of order $M^2 = O(p)$ p-adically so that the real counterpart of the p-adic mass would be of the order of elementary particle mass. Also now degeneracies of the states are gigantic. Unless p-adic and real string tensions are different, the mass of the corresponding real state is by a factor of order p higher ($\sim 10^{-4} \times \sqrt{p}$ Planck masses!). This can be seen as a strong objection either against the existence of light real counterparts of the exotic p-adic states or against the applicability of the canonical identification map outside the realm of p-adic thermodynamics.

It is not clear whether super-canonical degeneracy is present for the quaternion conformal representations. In fact, it might be that quaternion conformal representations are associated with CP_2 type extremals representing elementary particles and cannot be assigned to the light-like boundaries of MEs. This would mean that the boundaries of MEs represent completely new form of light-like matter. Massless states with super-canonical conformal weight $L_0 = O(p)$ are possible and momentum scale for these states is naturally determined by p. They define a more promising fractal hierarchy of life forms.

The lowest quaternion-conformal life form in the hierarchy are states having mass squared $M^2 \propto L_0 = O(p)$ could be called first order life[1]. These states have masses which are same order of magnitude as the masses of elementary particles with same value of p but have nothing to do with

[1]Note that also Super Virasoro representations associated with ordinary particles allow light excitations with $L_0 - n_0 = O(p)$.

the elementary particles themselves. The extremely weak direct interaction between these these representations and ordinary elementary particles might mean that these life forms do not affect elementary particle physics directly. On the other hand, there is intriguing numerical evidence that non-perturbative aspects of hadron physics might be understood if transition from high energy hadron physics to low energy hadron physics corresponds to a phase transition replacing ordinary Super Virasoro representations with exotic Super Virasoro representations (Regge slope and pion mass are predicted with few percent accuracy: see the chapter [F5]. This result is intriguing and forces to keep mind open for new interpretations of the p-adicity. Life requires also the presence of macroscopic quantum phases and one cannot therefore exclude the possibility of hadronic life when macroscopic quantum phases like Bose-Einstein condensates of pions or of super conducting neutron pairs are possible. Neutron super-conductivity is indeed believed to be possible in neutron stars.

To generate first order life forms in elementary particle length scales one would need MEs with wavelengths of order elementary particle Compton length. Presumably also temperature should be in interval around the energy defined by the secondary p-adic length scale. The Darwinian selection implied by self-organization should select some preferred p-adic primes as winners in the struggle for survival. Elementary particles are survivers at the lowest level and the first guess is that the primes corresponding to elementary particles provide good candidates for survivers at higher levels. The p-adic length scale $L(169) \simeq 5.1$ microns associated with neutrinos is especially interesting as far as first order life is considered and could (actually should, as the model of memetic code suggests) be an essential aspect of life in cell length scale.

Also the other primary p-adic lengths scales seem to be important for the structure of bio-matter, which suggests that first order life in these length scales is important for the understanding of living matter.

8.4.2 Higher order life forms in biologically interesting length scales

$L_0 = O(p^n)$ $n \geq 1$, representations of p-adic super-canonical algebra defining 'n:th order life' are especially interesting as far as living matter is considered. The reason is that the energy scale for these excitations is so small that the 'matter-mind interaction' with low frequency classical fields associated with MEs becomes possible. There seems to be no obvious difference between life forms with different values of n having p-adic length scales $L(n,k)$ of same order of magnitude as far as degeneracy of states is considered. However, if the negentropy gain in single quantum jump is limited by $log(p)$ or $plog(p)$ as the simplest scenario suggests [H2]), then first order life forms have potential for more information rich conscious experiences than higher order life forms with roughly the same p-adic length scale. Also the estimate for the maximal number of primary qualia allows more primary qualia for first order life forms.

What makes the hypothesis so interesting is that the number of interesting-to-us p-adic length scales associated with the exotic representations is rather small. Especially interesting are the secondary p-adic length- and time scales defined by Mersenne primes. Mersenne primes M_{89}, M_{107} and M_{127} define fundamental p-adic length scale in elementary particle physics and correspond to intermediate gauge bosons, hadrons and electron. M_{61} could correspond also to new ultra high energy physics. The natural guess is that secondary p-adic length scales, and those associated with Mersenne primes in particular, are especially important for consciousness and life.

1. Higher order life in nanoscales

The secondary p-adic length associated with M_{61} is $L(127)/2^{3/2}$ and is slightly below electron length scale. Besides primary p-adic length scales $L(k)$, $k = 127, 131, 137, 139$ listed in table below, also the secondary p-adic length scales $L_2(k) = L(2k)$, $k = 67, 71, 73$ and even the tertiary length scales $L_3(43) = L(129)$ and $L_3(47) = L(141)$ could have been important for the evolution of bio-intelligence. $L_2(67)$ is .28 Angstroms, $L_3(47) = 3.1$ Angstroms, $L_2(71) = 4.4$ Angstroms and

$L_2(73) = 1.8$ nanometers might be crucial for self-organization and intelligence at level of DNA and proteins. Thus the miracles of biochemical self-organization would not be reducible to standard chemistry but would involve in absolutely essential manner the symbiosis with higher life forms. The energy scale involved is in nanometer length scales of order keV and seems quite too high for life: room temperature which corresponds to 10^{-2} eV or at least the energy scale of atomic transitions seems to be the natural energy scale in protein length scales.

k	127	131	67_2	137	139	71_2	73_2
$L(k,n)/10^{-10}m$	.025	.1	.28	.8	1.6	4.5	18.0

Table 1. p-Adic length scales $L(k,n)$ possibly relevant to consciousness and life in atomic and nanolength scales. The length scale $L(151)$ is taken to be the thickness of cell membrane, which is 10^{-8} meters in a good approximation.

2. Higher order life forms in subcellular length scales and retina as living creature

First order life forms in subcellular length scales correspond to $k = 149, 151, 157, 163, 167$ and 169: corresponding p-adic length scales vary in the range of 5 nanometers and 5 micrometers and are given in the table below. Second order life forms associated with $L_2(79) = L(158) = 113$ nanometers, $L_2(83) = L(166) = 1.8$ micrometers as well as third order life form associated with $L_3(53) = L(159) = 160$ nanometers could also be important for self-organization and intelligence at subcellular levels. The energies for the secondary excitations of $k = 83$ Super Virasoro are in the region of visible light and an interesting possibility is that that these excitations might be excited when photons are absorbed by retina and that retina could be regarded as an intelligent conscious living being. This would also partially explain why our vision is just in this particular wavelength range. To decide whether interaction between photons and secondary Super Virasoro excitations is strong enough one should be able to device a model for this interaction.

k	149	151	157	79_2	53_3	163	83_2	167	169
$L_p/10^{-8}m$	.5	1	8	11.3	16	64	181	256	512

Table 2. p-Adic length scales $L(k,n)$ possibly relevant to consciousness and life between cell membrane and cellular length scales.

3. Higher order life in submillimeter length scales

The length scale range between $k = 169$ and $k = 191$ contains primary length scales $k = 173, 179, 181$ given in table below, secondary length scale $L_2(89) = L(178) = 1.1 \times 10^{-4}$ meters, and tertiary length scale $L_3(59) = L(177) = .8 \times 10^{-4}$ meters. The special importance of Mersenne primes suggests M_{89} second order life have managed to survive and might have meant a breakthrough in evolution. The size scale of largest neurons, say pyramidal neurons in cortex is indeed of order $L_2(M_{89})$. The fact that the lengths of micro-tubuli inside axons have length of order 10^{-4} meters suggests that they are accompanied by MEs corresponding to M_{89}. This hypothesis is inspired also by quantum antenna hypothesis and by the notion that MEs associated with axons serve as neural windows. The frequency scale associated with M_{89} is 3.3×10^{12} Hz and in infrared range. The energies involved correspond to 10^{-12} eV which is the thermal energy associated with the room temperature. This might explain the crucial importance of temperature for biolife. In too low temperatures secondary Super Virasoro excitations would be frozen whereas in too high temperatures situation would be thermalized.

k	173	59_3	89_2	179	181
$L_p/10^{-4}m$	.2	.8	1.1	1.6	3.2

Table 4. p-Adic length scales $L(k,n)$ possibly relevant to consciousness and life between cellular and submillimeter length scales.

IR radiation is known to be important for odor perception of at least insects [49]: the energies of $k = 89$ Super Virasoro are in this energy range. The structure of olfactory receptors also resembles the structure of the photoreceptors in retina. This would suggest that odor (and possibly also taste) perception might be regarded basically as IR vision with various odors playing the role of colors. The large number of different odors suggests that the number of different 'cones' is much higher than in the case of vision. The secondary p-adic length scale associated with M_{89} could give rise to secondary excitations of electro-weak fields with huge degeneracies. If the size of the 'pixel' characterizing sensory experience corresponds to the p-adic length scale of Super Virasoro associated with primary sensory organ, then one must conclude that also tactile senses could correspond to M_{89} or some smaller prime. Quite generally, vision, olfaction (and possibly also tastes) and tactile senses could thus be related with the secondary p-adic length scales $L_2(83)$ and $L_2(89)$ and/or with the primary length scales $L(169)$ and $L(173)$ and $L(179) = \sqrt{2}L_2(89)$. Note that the classical gauge fields associated with MEs could be used to generate secondary sensory experiences in longer p-adic length scales.

4. Higher order life forms in human length scales

The length scale range relevant to the structures of human brain contains the primary length scales corresponding to $k = 191, 193, 197$ and 199 varying in the range of 1-16 cm and are listed in the table below. The secondary and tertiary length scales $L_2(97) = 2.8$ cm, $L_3(67) = .32$ meters, $L_2(101) = .45$ meters and $L_2(103) = 1.81$ meters covers length scale range between brain nuclei and human body size. The fact that these primes correspond to the p-adic length scales associated with elementary particles (quarks) suggest that also second order life in these length scales is winner in the fight for survival. $L_2(97)$ corresponds to the size scale of brain nuclei which suggests that single pixel now provides a summary about sensory experience of brain nucleus. For instance, 'amygdalar emotions' might be in question.

It could be that the mind like space-times sheet with the size of brain and other body parts and entire body correspond carries exotic representations of $k = 67_3$, $k = 101_2$ and $k = 103_2$ Super Virasoro. The hypothesis that these levels correspond to emotions understood as generalized sensory experiences about the state of body solve the puzzles why emotions are 'single pixel' emotions and determined by the state of body. Secondary p-adic length scale should determine the size of the pixel in the bitmap provided by generalized sensory experience: since the size of pixel is of order human brain or even body, one could understand why emotions are 'single-pixel' emotions. Note that 'our experience' about these emotions probably does not correspond to this experience but experience coded to ELF level of self hierarchy. Body length scale would be associated with 'body-consciousness' quite different from our consciousness which corresponds to much higher level of the hierarchy.

k	191	193	97_2	197	199	67_3	101_2	103_2
L_p/m	.01	.02	2.8	.08	.16	.32	.45	1.8

Table 5. p-Adic length scales $L(k,n)$ possibly relevant to consciousness and life at length scales relevant to human brain and body.

5. Higher order life above body length scale

The primary p-adic length scales $k = 211, 223, 227,\ 229, 233, 239,\ 241$ and 251 between body size and $L_2(127)$ (quite near to Earth's circumference), and also longer p-adic length scales are listed in the table above. This range contains the secondary length scales $k = 107, 113$ and $k = 127$ correspond to a hierarchy of collective consciousness from the point of view of body (but, as it

seems, not from our point of view!). The reader is encouraged to find the tertiary length scales in this range.

k	211	71_3	107_2	109_2	223
L_p/m	10	20	28.3	113	640
$T_p/\mu s$	3.3E-2	6.6E-2	9.2E-2	.37	2.1
k	113_2	227	229	233	79_3
L_p/m	1.8E+3	$2.5E+3$	$5E+3$	$2E+4$	8E+4
$T_p/\mu s$	6.1	8.6	17	69	276
k	239	241	$3^5 = 243$	83_3	2_2^5
L_p/m	$1.6E+5$	$3.2E+5$	6.4E+5	5.1E+6	7.2E+6
T_p/ms	.55	1.1	2.2	17.6	24.9
k	251	127_2	257	131_2	263
L_p/m	$E+7$	2.8E+7	$8E+7$	44.8	$6.4E+8$
T_p	35 ms	.1 s	.28 s	1.6 s	2.26 s
k	269	271	137_2	277	139_2
L_p/m	$5E+9$	$E+10$	2.8E+10	$7.7E+10$	11.2E+10
T_p	18.1 s	36.2 s	1.7 min	4.3 min	6.1 min
k	281	283	289	97_3	293
L_p/m	3.2E+11	6.4E+11	$5.2E+12$	1.1E+13	$2.1E+13$
T_p	17.3 min	34.6 min	4.6 h	6.3 h	18.5 h
k	149_2	151_2	101_3	307	103_3
L_p/ld	4.9	19.5	27.6	98.6	197.2
T_p/d	4.9	19.5	27.6	98.6	197.2

Table 6. p-Adic length and time scales above length scale $L(211) = 10$ meters possibly relevant to life and consciousness.

The emergence of Mersenne prime M_{107} could perhaps be associated with the emergence of social groups. Amusingly, M_{107} is hadronic length scale and associated with the emergence of color confined many-quark states, kind of societies also these! More seriously, color confinement should make sense also for the exotic Super Virasoro representations and might have some counterpart at the level of consciousness. For M_{107} the p-adic length scale is about 29.0 meters, which is between $L(211) = 10.2$ meters and $L(223) = 655$ meters. The corresponding frequency scale is 6 MHz. $L_2(113) \simeq 1853$ meters is the length scale associated with the next secondary Super Virasoro.

The tertiary length scales $L_3(83) = L(249)$, $L_2(k = 5^3 = 125) = L(250)$; secondary length scale $L_2(127)$, and the primary p-adic length scales $L(251), L_2(127)$, $L(2^{2^8}) = L(256)$ and $L(257)$ correspond to the sequence of fundamental Super Virasoro frequencies

$$\frac{f(1,0)}{Hz} \in \{56.4, 40, 28.2, 10.0, 5.0, 3.5\} \ ,$$

which are important resonance frequencies of EEG which strongly encouratges the view that exotic Super Virasoro are involved with our qualia.

M_{127} corresponds to Earth size and to frequency of 10 Hz which is in EEG range. Next Mersenne prime corresponds to a completetely super-astronomical length scale. Uncertainty Principle suggests that if EEG frequencies stimulate the quantum transitions giving rise to our conscious experiences, then our mental images should correspond to MEs with $k = 127$ and 131. $k = 131$ indeed corresponds to frequencies above .63 Hz (1.6 seconds) covering delta, theta and alpha frequencies up to 10 Hz where the range of $k = 127$ frequencies begins (note however that

the difference of M_{127} energies can be also below 10 Hz). Also the basic rhythms of body (heart beat and respiration) could correspond to $k = 131$ time scales.

The next secondary p-adic time scales corresponding to $k = 137, 139, 149$ and $k = 151$. $T_2(137)$ is are 1 minute 40 seconds, $T_2(139)$ is 6 minutes 40 seconds, $T_2(149)$ is 4.2 days roughly, $T_2(151)$ is 16.8 days roughly. $T_2(157)$ is roughly 1078.5 days (roughly three years). $T_2(163)$ is roughly 69024 days which makes roughly 189 years. These time scales could be important for human life cycle and the secondary excitations of these Super Virasoros could define important biological rhythms.

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