

# Dark Forces and Living Matter

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November 30, 2016

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### Abstract

The unavoidable presence of classical long ranged weak (and also color) gauge fields in TGD Universe has been a continual source of worries for more than two decades. The basic question has been whether electro-weak charges of elementary particles are screened in electro-weak length scale or not. The TGD based view about dark matter assumes that weak charges are indeed screened for ordinary matter in electro-weak length scale but that dark electro-weak bosons correspond to much longer symmetry breaking length scale. The localization of the modes of Kähler-Dirac action to 2-D surfaces at which  $W$  fields vanish realizes this idea concretely. Also  $Z^0$  fields can vanish and are expected to do so above weak scale.

The large value of  $\hbar$  in dark matter phase implies that Compton lengths and -times are scaled up. In particular, the sizes of nucleons and nuclei become of order atom size so that dark nuclear physics would have direct relevance for condensed matter physics. It becomes impossible to make a reductionistic separation between nuclear physics and condensed matter physics and chemistry anymore. This view forces a profound re-consideration of the earlier ideas in nuclear and condensed physics context. It however seems that most of the earlier ideas related to the classical  $Z^0$  force and inspired by anomaly considerations survive in a modified form.

The weak form of electric-magnetic duality led to the identification of the long sought for mechanism causing the weak screening in electroweak scales. The basic implication of the duality is that Kähler electric charges of wormhole throats representing particles are proportional to Kähler magnetic charges so that the  $CP_2$  projections of the wormhole throats are homologically non-trivial. The Kähler magnetic charges do not create long range monopole fields if they are neutralized by wormhole throats carrying opposite monopole charges and weak isospin neutralizing the axial isospin of the particle's wormhole throat. One could speak of confinement of weak isospin. The weak field bodies of elementary fermions would be replaced with string like objects with a length of order  $W$  boson Compton length. Electro-magnetic flux would be feeded to electromagnetic field body where it would be feeded to larger space-time sheets. Similar mechanism could apply in the case of color quantum numbers. Weak charges would be therefore screened for ordinary matter in electro-weak length scale but dark electro-weak bosons correspond to much longer symmetry breaking length scale for weak field body. Large values of Planck constant would make it possible to zoop up elementary particles and study their internal structure without any need for gigantic accelerators.

One can still worry about large parity breaking effects - say in nuclear physics- since the couplings of spinors to classical weak fields are there. Around 2012 it became clear that the condition that induced spinor fields have well defined em charge localizes their modes in the generic case to 2-surfaces carrying vanishing induced  $W$  gauge fields. It is quite possible that this localization is consistent with Kähler-Dirac equation only in their Minkowskian regions were the effective metric defined by Kähler-Dirac gamma matrices can be effectively 2-dimensional.

One can pose the additional condition that also classical  $Z^0$  field vanishes - at least above weak scale. Fundamental fermions would experience only em field so that the worries related to large parity breaking effects would disappear. The proportionality of weak scale to  $h_{eff} = n \times h$  however predicts that weak fields are effectively massless belong scaled up weak scale. Therefore worries about large parity breaking effects in ordinary nuclear physics can be forgotten.

In this chapter possible implications of the dark weak force for the understanding of living matter are discussed. The basic question is how classical  $Z^0$  fields could make itself visible. Large parity breaking effects in living matter suggests which direction one should look for the answer to the question. One possible answer is based on the observation that for vacuum extremals classical electromagnetic and  $Z^0$  fields are proportional to each other and this means that the electromagnetic charges of dark fermions standard are replaced with effective couplings in which the contribution of classical  $Z^0$  force dominates. This modifies dramatically the model for the cell membrane as a Josephson junction and raises the scale of Josephson energies from IR range just above thermal threshold to visible and ultraviolet. The amazing finding is that the Josephson energies for biologically important ions correspond to the energies assigned to the peak frequencies in the biological activity spectrum of photoreceptors in retina suggesting. This suggests that almost vacuum extremals and thus also classical  $Z^0$  fields could be in a central role in the understanding of the functioning of the cell membrane and of sensory qualia. This would also explain the large parity breaking effects in living matter.

A further conjecture is that EEG and its predicted fractally scaled variants which same energies in visible and UV range but different scales of Josephson frequencies correspond to Josephson photons with various values of Planck constant. The decay of dark ELF photons

with energies of visible photons would give rise to bunches of ordinary ELF photons. Biophotons in turn could correspond to ordinary visible photons resulting in the phase transition of these photons to photons with ordinary value of Planck constant. This leads to a very detailed view about the role of dark electromagnetic radiation in biomatter and also to a model for how sensory qualia are realized. The general conclusion might be that most effects due to the dark weak force are associated with almost vacuum extremals.

## 1 Introduction

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In its original form this chapter was an attempt to concretize and develop ideas related to dark matter by using some experimental inputs with emphasis on the predicted interaction between the new nuclear physics and condensed matter. As the vision about dark matter became more coherent and the nuclear string model developed in its recent form, it became necessary to update the chapter and throw away the obsolete material. I dare hope that the recent representation is more focused than the earlier one.

## 1.1 Evidence For Long Range Weak Forces And New Nuclear Physics

There is a lot of experimental evidence for long range electro-weak forces, dark matter, and exotic nuclear physics giving valuable guidelines in the attempts to build a coherent theoretical scenario.

### 1.1.1 Cold fusion

Cold fusion [C2] is a phenomenon involving new nuclear physics and the known selection rules give strong constraints when one tries to understand the character of dark nuclear matter. The simplest model for cold fusion found hitherto is based on the nuclear string model [L2]. [L2] and will be taken as the basis of the considerations of this chapter. Also comparisons with the earlier variant of model of cold fusion [K23] will be made in the section about cold fusion.

### 1.1.2 Large parity breaking effects

Large parity breaking effects in living matter indicate the presence of long ranged weak forces, and the reported nuclear transmutations in living matter [C1, C10] suggest that new nuclear physics plays a role also now. For instance, the Gaussian Mersennes  $(1+i)^k - 1$  for  $k = 113, 151, 157163, 167$  could correspond to weak length scales and four biologically important length scales in the range 10 nm-25  $\mu\text{m}$ , which seem to relate directly to the coiling hierarchy of DNA double strands.

### 1.1.3 Anomalies of the physics of water

The physics of water involves a large number of anomalies and life depends in an essential manner on them. As many as 41 anomalies are discussed in the excellent web page “Water Structure and Behavior” of M. Chaplin [D8]. The fact that the physics of heavy water differs much more from that of ordinary water as one might expect on basis of different masses of water molecules suggests that dark nuclear physics is involved.

1. The finding that one hydrogen atom per two water molecules remain effectively invisible in neutron and electron interactions in atto-second time scale [D8, D6] suggests that water is partially dark. These findings have been questioned in [D10] and thought to be erroneous in [D3]. If the findings are real, dark matter phase made of super-nuclei consisting of protons connected by dark color bonds could explain them as perhaps also the clustering of water molecules predicting magic numbers of water molecules in clusters. If so, dark nuclear physics could be an essential part of condensed matter physics and biochemistry. For instance, the condensate of dark protons might be essential for understanding the properties of biomolecules and even the physical origin of van der Waals radius of atom in van der Waals equation of state.
2. The observation that the binding energy of dark color bond for  $n = 2^{11} = 1/v_0$  of the scaling of  $\hbar$  corresponds to the bond energy 5 eV of hydrogen bond raises the fascinating possibility that hydrogen bonds is accompanied by a color bond between proton and oxygen nucleus. Also more general chemical bonds might be accompanied by color bonds so that dark color physics might be an essential part of molecular physics. Color bonds might be also responsible for the formation of liquid phase and thus solid state. Dark weak bonds between nuclei could be involved and might be responsible for the repulsive core of van der Waals force and be part of molecular physics too. There is evidence for two kinds of hydrogen bonds [D7] : a possible identification is in terms of p-adic scaling of hydrogen bonds by a factor 2. This kind of doubling is predicted by nuclear string model [L2], [L2].
3. Years after writing this piece of text emerged the idea that covalent bonds of biopolymers might be accompanied by color bonds carrying the metabolic energy liberated in the decay of these polymers [K14]. Polymer like sequences of “half-dark” water molecules with one dark proton with dark protons connected by color bonds to form dark nucleus could have emerged as prebiotic counterparts of biomolecules and carry metabolic energy in color bonds and realize genetic code [K12, L2]. They could accompany ordinary bio-bolymers in water environment and color bonds could carry the metabolic energy. There are of course many other options, and one must have open mind since the belief that biochemistry is understood reduces to high extent to the belief in the reductionistic dogma.

4. Tetrahedral water clusters consisting of 14 water molecules would contain 8 dark protons which corresponds to a magic number for a dark nucleus consisting of protons. Icosahedral water clusters in turn consist of 20 tetrahedral clusters. This raises the question whether fractally scaled up super-nuclei could be in question. If one accepts the vision about dark matter hierarchy based in Jones inclusions to be discussed briefly later, tetrahedral and icosahedral structures of water could correspond directly to the unique genuinely 3-dimensional  $G_a = E_6$  and  $E_8$  coverings of  $CP_2$  with  $n_a = 3$  and  $n_a = 5$  assignable to dark electrons. Icosahedral structures are also very abundant in living matter, mention only viruses.

#### 1.1.4 Other anomalies

There are also other anomalies which might relate to the hierarchy of Planck constants and also to dark weak forces.

##### 1. Exotic chemistries

Exotic chemistries [D9] in which clusters of atoms of given given type mimic the chemistry of another element. These systems behave as if nuclei would form a jellium (constant charge density) defining a harmonic oscillator potential for electrons. Magic numbers correspond to full electron shells analogous to noble gas elements. It is difficult to understand why the constant charge density approximation works so well. If nuclear protons are in large  $\hbar(M^4)$  phase with Fermat integer  $n_F = 3 \times 2^{11}$ , the electromagnetic sizes of nuclei would be about 2.4 Angstroms and the approximation would be natural.

As a matter, fact nuclear string model predicts that the nuclei can have as many as  $3A$  exotic charge states obtained by giving neutral color bond charge  $\pm 1$ : this would give rise to quite different kind of alchemy [L2]. [L2] revealing itself in cold fusion.

##### 2. Free energy anomalies

The anomalies reported by free energy researchers such as over unity energy production in devices involving repeated formation and dissociation of  $H_2$  molecules based on the original discovery of Nobelist Irwing Langmuir [D5] (see for instance [H5] ) suggest that part of  $H$  atoms might end up to dark matter phase liberating additional energy. The “mono-atomic” elements of Hudson suggest also dark nuclear physics [H2]. There is even evidence for macroscopic transitions to dark phase [H10, H6, H4].

##### 3. Tritium beta decay anomaly and findings of Shnoll

Tritium beta decay anomaly [C4, C6, C9, C7] suggests exotic nuclear physics related to weak interactions. The evidence for the variation of the rates of nuclear and chemical processes correlating with astrophysical periods [E1] , [E1] could be understood in terms of weak fields created by dark matter and affect by astrophysical phenomena.

## 1.2 Dark Rules

I have done a considerable amount of trials and errors in order to identify the basic rules allowing to understand what it means to be dark matter is and what happens in the phase transition to dark matter. It is good to try to summarize the basic rules of p-adic and dark physics allowing to avoid obvious contradictions.

### 1.2.1 The notion of field body

The notion of “field body” implied by topological field quantization is essential. There would be em,  $Z_0$ ,  $W$ , gluonic, and gravitonic field bodies, each characterized by its one prime. The motivation for considering the possibility of separate field bodies seriously is that the notion of induced gauge field means that all induced gauge fields are expressible in terms of four  $CP_2$  coordinates so that only single component of a gauge potential allows a representation as and independent field quantity. Perhaps also separate magnetic and electric field bodies for each interaction and identifiable as flux quanta must be considered. This kind of separation requires that the fermionic content of the flux quantum (say fermion and anti-fermion at the ends of color flux tube) is such that it conforms with the quantum numbers of the corresponding boson.

What is interesting that the conceptual separation of interactions to various types would have a direct correlate at the level of space-time topology. From a different perspective inspired by the general vision that many-sheeted space-time provides symbolic representations of quantum physics, the very fact that we make this conceptual separation of fundamental interactions could reflect the topological separation at space-time level.

The p-adic mass calculations for quarks encourage to think that the p-adic length scale characterizing the mass of particle is associated with its electromagnetic body and in the case of neutrinos with its  $Z^0$  field body.  $Z^0$  field body can contribute also to the mass of charged particles but the contribution would be small. It is also possible that these field bodies are purely magnetic for color and weak interactions. Color flux tubes would have exotic fermion and anti-fermion at their ends and define colored variants of pions. This would apply not only in the case of nuclear strings but also to molecules and larger structures so that scaled variants of elementary particles and standard model would appear in all length scales as indeed implied by the fact that classical electro-weak and color fields are unavoidable in TGD framework.

One can also go further and distinguish between magnetic field body of free particle for which flux quanta start and return to the particle and “relative field” bodies associated with pairs of particles. Very complex structures emerge and should be essential for the understanding the space-time correlates of various interactions. In a well-defined sense they would define space-time correlate for the conceptual analysis of the interactions into separate parts. In order to minimize confusion it should be emphasized that the notion of field body used in this chapter relates to those space-time correlates of interactions, which are more or less *static* and related to the formation of *bound states*.

### 1.2.2 What dark variant of elementary particle means

It is not at all clear what the notion of dark variant of elementary particle or of larger structures could mean.

#### 1. Are only field bodies dark?

One variety of dark particle is obtained by making some of the field bodies dark by increasing the value of Planck constant. This hypothesis could be replaced with the stronger assumption that elementary particles are maximally quantum critical systems so that they are same irrespective of the value of the Planck constant. Elementary particles would be represented by partonic 2-surfaces, which belong to the universal orbifold singularities remaining invariant by all groups  $G_a \times G_b$  for a given choice of quantization axes. If  $G_a \times G_b$  is assumed to leave invariant the choice of the quantization axes, it must be of the form  $Z_{n_a} \times Z_{n_b} \subset SO(3) \times SU(3)$ . Partonic 2-surface would belong to  $M^2 \times CP_2/U(1) \times U(1)$ , where  $M^2$  is spanned by the quantization axis of angular momentum and the time axis defining the rest system.

A different manner to say this is that the  $CP_2$  type extremal representing particle would suffer multiple topological condensation on its field bodies so that there would be no separate “particle space-time sheet”.

Darkness would be restricted to particle interactions if it is assigned with topological field quanta mediating interactions. The value of the Planck constant would be assigned to a particular interaction between systems rather than system itself. This conforms with the original finding that gravitational Planck constant satisfies  $\hbar_{gr} = GM_1M_2/v_0$ ,  $v_0 \simeq 2^{-11}$ . Since each interaction can give rise to a hierarchy dark phases, a rich variety of partially dark phases is predicted. The standard assumption that dark matter is visible only via gravitational interactions would mean that gravitational field body would not be dark for this particular dark matter. Note however that gravitational Planck constant  $h_{fr}$  having gigantic values could have different origin as Planck constant  $h_{eff}$  emerging from considerations related to biology: this is discussed in [K22].

Complex combinations of dark field bodies become possible and the dream is that one could understand various phases of matter in terms of these combinations. All phase transitions, including the familiar liquid-gas and solid-liquid phase transitions, could have a unified description in terms of dark phase transition for an appropriate field body. At mathematical level Jones inclusions would provide this description.

The book metaphor for the interactions at space-time level is very useful in this framework. Elementary particles correspond to ordinary value of Planck constant analogous to the ordinary



sheets of a book and the field bodies mediating their interactions are the same space-time sheet or at dark sheets of the book.

2. *Can also elementary particles be dark?*

Also dark elementary particles themselves rather than only the flux quanta could correspond to dark space-time sheet defining multiple coverings of  $H/G_a \times G_b$ . This would mean giving up the maximal quantum criticality hypothesis in the case of elementary particles. These sheets would be exact copies of each other. If single sheet of the covering contains topologically condensed space-time sheet, also other sheets contain its exact copy.

The question is whether these copies of space-time sheet defining classical identical systems can carry different fermionic quantum numbers or only identical fermionic quantum numbers so that the dark particle would be exotic many-fermion system allowing an apparent violation of statistics ( $N$  fermions in the same state).

Even if one allows varying number of fermions in the same state with respect to a basic copy of sheet, one ends up with the notion of  $N$ -atom in which nuclei would be ordinary but electrons would reside at the sheets of the covering. The question is whether symbolic representations essential for understanding of living matter could emerge already at molecular level via the formation of  $N$ -atoms.

### 1.2.3 Criterion for the transition to dark phase

The criterion  $\alpha Q_1 Q_2 > 1$  for the transition to dark matter phase relates always to the interaction between two systems and the interpretation is that when the field strength characterizing the interaction becomes too strong, the interaction is mediated by dark space-time sheets which define  $n = n(G_a) \times n(G_b)$ -fold covering of  $M^4 \times CP_2/G_a \times G_b$ . The sharing of flux between different space-time sheets reduces the field strength associated with single sheet below the critical value.

### 1.2.4 Mersenne hypothesis

The generalization of the imbedding space means a book like structure for which the pages are products of singular coverings or factor spaces of CD (causal diamond defined as intersection of future and past directed light-cones) and of  $CP_2$  [K9]. This predicts that Planck constants are rationals and that given value of Planck constant corresponds to an infinite number of different pages of the Big Book, which might be seen as a drawback. If only singular covering spaces are allowed the values of Planck constant are products of integers and given value of Planck constant corresponds to a finite number of pages given by the number of decompositions of the integer to two different integers.

TGD inspired quantum biology and number theoretical considerations suggest preferred values for  $r = \hbar/\hbar_0$ . For the most general option the values of  $\hbar$  are products and ratios of two integers  $n_a$  and  $n_b$ . Ruler and compass integers defined by the products of distinct Fermat primes and power of two are number theoretically favored values for these integers because the phases  $\exp(i2\pi/n_i)$ ,  $i \in \{a, b\}$ , in this case are number theoretically very simple and should have emerged first in the number theoretical evolution via algebraic extensions of p-adics and of rationals. p-Adic length scale hypothesis favors powers of two as values of  $r$ .

One can however ask whether a more precise characterization of preferred Mersennes could exist and whether there could exist a stronger correlation between hierarchies of p-adic length scales and Planck constants. Mersenne primes  $M_k = 2^k - 1$ ,  $k \in \{89, 107, 127\}$ , and Gaussian Mersennes  $M_{G,k} = (1 + i)k - 1$ ,  $k \in \{113, 151, 157, 163, 167, 239, 241, \dots\}$  are expected to be physically highly interesting and up to  $k = 127$  indeed correspond to elementary particles. The number theoretical miracle is that all the four scaled up electron Compton lengths with  $k \in \{151, 157, 163, 167\}$  are in the biologically highly interesting range 10 nm-2.5  $\mu\text{m}$ ). The question has been whether these define scaled up copies of electro-weak and QCD type physics with ordinary value of  $\hbar$ . The proposal that this is the case and that these physics are in a well-defined sense induced by the dark scaled up variants of corresponding lower level physics leads to a prediction for the preferred values of  $r = 2^{k_d}$ ,  $k_d = k_i - k_j$ .

What induction means is that dark variant of exotic nuclear physics induces exotic physics with ordinary value of Planck constant in the new scale in a resonant manner: dark gauge bosons

transform to their ordinary variants with the same Compton length. This transformation is natural since in length scales below the Compton length the gauge bosons behave as massless and free particles. As a consequence, lighter variants of weak bosons emerge and QCD confinement scale becomes longer.

This proposal will be referred to as Mersenne hypothesis. It leads to strong predictions about EEG [K6] since it predicts a spectrum of preferred Josephson frequencies for a given value of membrane potential and also assigns to a given value of  $\hbar$  a fixed size scale having interpretation as the size scale of the body part or magnetic body. Also a vision about evolution of life emerges. Mersenne hypothesis is especially interesting as far as new physics in condensed matter length scales is considered: this includes exotic scaled up variants of the ordinary nuclear physics and their dark variants. Even dark nucleons are possible and this gives justification for the model of dark nucleons predicting the counterparts of DNA, RNA, tRNA, and amino-acids as well as realization of vertebrate genetic code [K25].

These exotic nuclear physics with ordinary value of Planck constant could correspond to ground states that are almost vacuum extremals corresponding to homologically trivial geodesic sphere of  $CP_2$  near criticality to a phase transition changing Planck constant. Ordinary nuclear physics would correspond to homologically non-trivial geodesic sphere and far from vacuum extremal property. For vacuum extremals of this kind classical  $Z^0$  field proportional to electromagnetic field is present and this modifies dramatically the view about cell membrane as Josephson junction. The model for cell membrane as almost vacuum extremal indeed led to a quantitative breakthrough in TGD inspired model of EEG and is therefore something to be taken seriously. The safest option concerning empirical facts is that the copies of electro-weak and color physics with ordinary value of Planck constant are possible only for almost vacuum extremals - that is at criticality against phase transition changing Planck constant.

### 1.3 Weak Form Of Electric Magnetic Duality, Screening Of Weak Charges, And Color Confinement?

TGD predicts the presence of long range classical weak fields and color fields and one should understand classically why quarks and leptons do not couple to these fields above weak boson length scale. Why the quarks inside ordinary nuclei do not generate long range weak fields and do not couple to them? Obviously the weak charges of quarks must be screened so that only electromagnetic charge remains. The extreme non-linearity of field equations in principle allows non-vanishing vacuum charge densities making possible this kind of screening. I have not been able to develop any detailed model for this.

A rather attractive looking explanation came with the discovery of electric-magnetic duality leading to a considerable progress in the understanding of basic quantum TGD. The basic implication of the duality is that Kähler electric charges of wormhole throats representing particles are proportional to Kähler magnetic charges so that the  $CP_2$  projections of the wormhole throats are homologically non-trivial. The Kähler magnetic charges do not create long range monopole fields if they are neutralized by wormhole throats carrying opposite monopole charges and weak isospin neutralizing the axial isospin of the particle's wormhole throat. One could speak of confinement of weak isospin. The weak field bodies of elementary fermions would be replaced with string like objects with a length of order W boson Compton length. Electro-magnetic flux would be feeded to electromagnetic field body where it would be feeded to larger space-time sheets. Similar mechanism could apply in the case of color quantum numbers.

One of the basic questions closely related to the weak screening have been whether it is possible to have a weak analog of the ordinary atom - say neutrino atom. Formally one can of course construct this kind of model and I have indeed done this. The recent view about the screening of weak forces does not however allow neutrino atoms since the weak gauge fluxes flow along flux tubes and are screened by opposite charges at their end rather than being spherically symmetric Coulomb fields. Elementary particles themselves can be regarded as string like objects neutralized above weak boson Compton length. The size of the magnetic flux tubes however scales as  $\sqrt{\hbar}$  so that large values of  $\hbar$  it is in principle possible to zoom up the elementary particles and see what their interior looks like. This applies to both weak and color forces and might some day make possible study of elementary particles without gigantic accelerators.

## 1.4 Dark Weak Forces And Almost Vacuum Extremals

TGD suggests strongly the presence of long range weak force and the large parity breaking in living matter realized as chiral selection provides support for it. One would however like some more concrete quantitative evidence for the conjecture that the classical weak forces are indeed there. This kind of evidence comes from the model of cell membrane based on the hypothesis that cell membrane correspond to almost vacuum extremal.

1. Induced Kähler form vanishes for vacuum extremals. The condition for vanishing implies that classical  $Z^0$  and electromagnetic fields are proportional to each other so that induced spinor field couples to both these fields. The assumption is that the quarks of nuclei and possibly also neutrinos correspond to a large value of Planck constant and therefore couple to the classical  $Z^0$  field. Atomic electrons would not have these couplings. This modifies dramatically the model for the cell membrane as a Josephson junction and raises the scale of Josephson energies from IR range just above thermal threshold to visible and ultraviolet. The amazing finding is that the Josephson energies for biologically important ions correspond to the energies assigned to the peak frequencies in the biological activity spectrum of photoreceptors in retina suggesting. This suggests that almost vacuum extremals and thus also classical  $Z^0$  fields could be in a central role in the understanding of the functioning of the cell membrane and of sensory qualia. This would also explain the large parity breaking effects in living matter.

One can construct also a generalization of Josephson junction as transmembrane protein such that Josephson energy is generalized to include also the difference of cyclotron energies over the membrane. This allows to understand the role of protons in metabolism and large value about 5 eV of metabolic energy quantum roughly 10 times larger than Josephson energy for cell membrane in terms of “square root of thermodynamics” replacing the ordinary thermodynamical model of cell membrane. In this case classical  $Z^0$  force is not necessary. It is of course possible that cell membrane proteins can be in two phases: without or with classical  $Z^0$  fields at string world sheets of dark fermions.

2. A further conjecture is that EEG and its predicted fractally scaled variants which same energies in visible and UV range but different scales of Josephson frequencies correspond to Josephson photons with various values of Planck constant. The decay of dark ELF photons with energies of visible photons would give rise to bunches of ordinary ELF photons. Biophotons in turn could correspond to ordinary visible photons resulting in the phase transition of these photons to photons with ordinary value of Planck constant. This leads to a very detailed view about the role of dark electromagnetic radiation in biomatter and also to a model for how sensory qualia are realized [K11, K20, K6].

What darkness means in the case of nuclei is that the “weak” field bodies of quarks are dark so that the size scale assignable to them is of order cell size. This does not affect their electromagnetic field bodies so that it is possible to speak about ions in the ordinary sense of the word. If the size scale of a given part of field body corresponds to the Compton length proportional to the p-adic length scale scaled up by  $\sqrt{\hbar}$  then cell membrane thickness as a Compton scale for the field body of weak bosons means rather large value of  $\hbar \sim 2^{151-89} = 2^{62}\hbar_0$ . This would scale down  $10^{14}$  Hz frequency of visible photons to about  $10^{-4}$  Hz.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. There are concept maps about topics related to the contents of the chapter prepared using CMAP realized as html files. Links to all CMAP files can be found at <http://tgdtheory.fi/cmaphtml.html> [L4]. Pdf representation of same files serving as a kind of glossary can be found at <http://tgdtheory.fi/tgdglossary.pdf> [L5]. The topics relevant to this chapter are given by the following list.

- Emergent ideas and notions [L6]
- Hierarchy of Planck constants [L7]
- Quantum gravity and biology [L8]

## 2 Weak Form Electric-Magnetic Duality And Its Implications

The notion of electric-magnetic duality [B2] was proposed first by Olive and Montonen and is central in  $\mathcal{N} = 4$  supersymmetric gauge theories. It states that magnetic monopoles and ordinary particles are two different phases of theory and that the description in terms of monopoles can be applied at the limit when the running gauge coupling constant becomes very large and perturbation theory fails to converge. The notion of electric-magnetic self-duality is more natural since for  $CP_2$  geometry Kähler form is self-dual and Kähler magnetic monopoles are also Kähler electric monopoles and Kähler coupling strength is by quantum criticality renormalization group invariant rather than running coupling constant. The notion of electric-magnetic (self-)duality emerged already two decades ago in the attempts to formulate the Kähler geometric of world of classical worlds. Quite recently a considerable step of progress took place in the understanding of this notion [K4]. What seems to be essential is that one adopts a weaker form of the self-duality applying at partonic 2-surfaces. What this means will be discussed in the sequel.

Every new idea must be of course taken with a grain of salt but the good sign is that this concept leads to precise predictions. The point is that elementary particles do not generate monopole fields in macroscopic length scales: at least when one considers visible matter. The first question is whether elementary particles could have vanishing magnetic charges: this turns out to be impossible. The next question is how the screening of the magnetic charges could take place and leads to an identification of the physical particles as string like objects identified as pairs magnetic charged wormhole throats connected by magnetic flux tubes.

1. The first implication is a new view about electro-weak massivation reducing it to weak confinement in TGD framework. The second end of the string contains particle having electroweak isospin neutralizing that of elementary fermion and the size scale of the string is electro-weak scale would be in question. Hence the screening of electro-weak force takes place via weak confinement realized in terms of magnetic confinement.
2. This picture generalizes to the case of color confinement. Also quarks correspond to pairs of magnetic monopoles but the charges need not vanish now. Rather, valence quarks would be connected by flux tubes of length of order hadron size such that magnetic charges sum up to zero. For instance, for baryonic valence quarks these charges could be  $(2, -1, -1)$  and could be proportional to color hyper charge.
3. The highly non-trivial prediction making more precise the earlier stringy vision is that elementary particles are string like objects: this could become manifest at LHC energies.
4. The weak form electric-magnetic duality together with Beltrami flow property of Kähler leads to the reduction of Kähler action to Chern-Simons action so that TGD reduces to almost topological QFT and that Kähler function is explicitly calculable. This has enormous impact concerning practical calculability of the theory.
5. One ends up also to a general solution ansatz for field equations from the condition that the theory reduces to almost topological QFT. The solution ansatz is inspired by the idea that all isometry currents are proportional to Kähler current which is integrable in the sense that the flow parameter associated with its flow lines defines a global coordinate. The proposed solution ansatz would describe a hydrodynamical flow with the property that isometry charges are conserved along the flow lines (Beltrami flow). A general ansatz satisfying the integrability conditions is found.

The strongest form of the solution ansatz states that various classical and quantum currents flow along flow lines of the Beltrami flow defined by Kähler current (Kähler magnetic field associated with Chern-Simons action). Intuitively this picture is attractive. A more general ansatz would allow several Beltrami flows meaning multi-hydrodynamics. The integrability conditions boil down to two scalar functions: the first one satisfies massless d'Alembert equation in the induced metric and the the gradients of the scalar functions are orthogonal. The interpretation in terms of momentum and polarization directions is natural.

## 2.1 Could A Weak Form Of Electric-Magnetic Duality Hold True?

Holography means that the initial data at the partonic 2-surfaces should fix the WCW metric. A weak form of this condition allows only the partonic 2-surfaces defined by the wormhole throats at which the signature of the induced metric changes. A stronger condition allows all partonic 2-surfaces in the slicing of space-time sheet to partonic 2-surfaces and string world sheets. Number theoretical vision suggests that hyper-quaternionicity *resp.* co-hyperquaternionicity constraint could be enough to fix the initial values of time derivatives of the imbedding space coordinates in the space-time regions with Minkowskian *resp.* Euclidian signature of the induced metric. This is a condition on modified gamma matrices and hyper-quaternionicity states that they span a hyper-quaternionic sub-space.

### 2.1.1 Definition of the weak form of electric-magnetic duality

One can also consider alternative conditions possibly equivalent with this condition. The argument goes as follows.

1. The expression of the matrix elements of the metric and Kähler form of WCW in terms of the Kähler fluxes weighted by Hamiltonians of  $\delta M_{\pm}^4$  at the partonic 2-surface  $X^2$  looks very attractive. These expressions however carry no information about the 4-D tangent space of the partonic 2-surfaces so that the theory would reduce to a genuinely 2-dimensional theory, which cannot hold true. One would like to code to the WCW metric also information about the electric part of the induced Kähler form assignable to the complement of the tangent space of  $X^2 \subset X^4$ .
2. Electric-magnetic duality of the theory looks a highly attractive symmetry. The trivial manner to get electric magnetic duality at the level of the full theory would be via the identification of the flux Hamiltonians as sums of of the magnetic and electric fluxes. The presence of the induced metric is however troublesome since the presence of the induced metric means that the simple transformation properties of flux Hamiltonians under symplectic transformations -in particular color rotations- are lost.
3. A less trivial formulation of electric-magnetic duality would be as an initial condition which eliminates the induced metric from the electric flux. In the Euclidian version of 4-D YM theory this duality allows to solve field equations exactly in terms of instantons. This approach involves also quaternions. These arguments suggest that the duality in some form might work. The full electric magnetic duality is certainly too strong and implies that space-time surface at the partonic 2-surface corresponds to piece of  $CP_2$  type vacuum extremal and can hold only in the deep interior of the region with Euclidian signature. In the region surrounding wormhole throat at both sides the condition must be replaced with a weaker condition.
4. To formulate a weaker form of the condition let us introduce coordinates  $(x^0, x^3, x^1, x^2)$  such  $(x^1, x^2)$  define coordinates for the partonic 2-surface and  $(x^0, x^3)$  define coordinates labeling partonic 2-surfaces in the slicing of the space-time surface by partonic 2-surfaces and string world sheets making sense in the regions of space-time sheet with Minkowskian signature. The assumption about the slicing allows to preserve general coordinate invariance. The weakest condition is that the generalized Kähler electric fluxes are apart from constant proportional to Kähler magnetic fluxes. This requires the condition

$$J^{03} \sqrt{g_4} = K J_{12} . \quad (2.1)$$

A more general form of this duality is suggested by the considerations of [K13] reducing the hierarchy of Planck constants to basic quantum TGD and also reducing Kähler function for preferred extremals to Chern-Simons terms [B1] at the boundaries of CD and at light-like wormhole throats. This form is following

$$J^{n\beta} \sqrt{g_4} = K \epsilon \times \epsilon^{n\beta\gamma\delta} J_{\gamma\delta} \sqrt{g_4} . \quad (2.2)$$

Here the index  $n$  refers to a normal coordinate for the space-like 3-surface at either boundary of CD or for light-like wormhole throat.  $\epsilon$  is a sign factor which is opposite for the two ends of CD. It could be also opposite of opposite at the opposite sides of the wormhole throat. Note that the dependence on induced metric disappears at the right hand side and this condition eliminates the potentials singularity due to the reduction of the rank of the induced metric at wormhole throat.

5. Information about the tangent space of the space-time surface can be coded to the WCW metric with loosing the nice transformation properties of the magnetic flux Hamiltonians if Kähler electric fluxes or sum of magnetic flux and electric flux satisfying this condition are used and  $K$  is symplectic invariant. Using the sum

$$J_e + J_m = (1 + K)J_{12} , \quad (2.3)$$

where  $J$  denotes the Kähler magnetic flux, , makes it possible to have a non-trivial WCW metric even for  $K = 0$ , which could correspond to the ends of a cosmic string like solution carrying only Kähler magnetic fields. This condition suggests that it can depend only on Kähler magnetic flux and other symplectic invariants. Whether local symplectic coordinate invariants are possible at all is far from obvious, If the slicing itself is symplectic invariant then  $K$  could be a non-constant function of  $X^2$  depending on string world sheet coordinates. The light-like radial coordinate of the light-cone boundary indeed defines a symplectically invariant slicing and this slicing could be shifted along the time axis defined by the tips of CD.

### 2.1.2 *Electric-magnetic duality physically*

What could the weak duality condition mean physically? For instance, what constraints are obtained if one assumes that the quantization of electro-weak charges reduces to this condition at classical level?

1. The first thing to notice is that the flux of  $J$  over the partonic 2-surface is analogous to magnetic flux

$$Q_m = \frac{e}{\hbar} \oint B dS = n .$$

$n$  is non-vanishing only if the surface is homologically non-trivial and gives the homology charge of the partonic 2-surface.

2. The expressions of classical electromagnetic and  $Z^0$  fields in terms of Kähler form [L1] , [L1] read as

$$\begin{aligned} \gamma &= \frac{e F_{em}}{\hbar} = 3J - \sin^2(\theta_W) R_{03} , \\ Z^0 &= \frac{g_Z F_Z}{\hbar} = 2R_{03} . \end{aligned} \quad (2.4)$$

Here  $R_{03}$  is one of the components of the curvature tensor in vielbein representation and  $F_{em}$  and  $F_Z$  correspond to the standard field tensors. From this expression one can deduce

$$J = \frac{e}{3\hbar} F_{em} + \sin^2(\theta_W) \frac{g_Z}{6\hbar} F_Z . \quad (2.5)$$

3. The weak duality condition when integrated over  $X^2$  implies

$$\begin{aligned} \frac{e^2}{3\hbar}Q_{em} + \frac{g_Z^2 p}{6}Q_{Z,V} &= K \oint J = Kn \ , \\ Q_{Z,V} &= \frac{I_V^3}{2} - Q_{em} \ , \ p = \sin^2(\theta_W) \ . \end{aligned} \quad (2.6)$$

Here the vectorial part of the  $Z^0$  charge rather than as full  $Z^0$  charge  $Q_Z = I_L^3 + \sin^2(\theta_W)Q_{em}$  appears. The reason is that only the vectorial isospin is same for left and right handed components of fermion which are in general mixed for the massive states.

The coefficients are dimensionless and expressible in terms of the gauge coupling strengths and using  $\hbar = r\hbar_0$  one can write

$$\begin{aligned} \alpha_{em}Q_{em} + p\frac{\alpha_Z}{2}Q_{Z,V} &= \frac{3}{4\pi} \times rnK \ , \\ \alpha_{em} &= \frac{e^2}{4\pi\hbar_0} \ , \ \alpha_Z = \frac{g_Z^2}{4\pi\hbar_0} = \frac{\alpha_{em}}{p(1-p)} \ . \end{aligned} \quad (2.7)$$

4. There is a great temptation to assume that the values of  $Q_{em}$  and  $Q_Z$  correspond to their quantized values and therefore depend on the quantum state assigned to the partonic 2-surface. The linear coupling of the Kähler-Dirac operator to conserved charges implies correlation between the geometry of space-time sheet and quantum numbers assigned to the partonic 2-surface. The assumption of standard quantized values for  $Q_{em}$  and  $Q_Z$  would be also seen as the identification of the fine structure constants  $\alpha_{em}$  and  $\alpha_Z$ . This however requires weak isospin invariance.

### 2.1.3 The value of $K$ from classical quantization of Kähler electric charge

The value of  $K$  can be deduced by requiring classical quantization of Kähler electric charge.

1. The condition that the flux of  $F^{03} = (\hbar/g_K)J^{03}$  defining the counterpart of Kähler electric field equals to the Kähler charge  $g_K$  would give the condition  $K = g_K^2/\hbar$ , where  $g_K$  is Kähler coupling constant which should invariant under coupling constant evolution by quantum criticality. Within experimental uncertainties one has  $\alpha_K = g_K^2/4\pi\hbar_0 = \alpha_{em} \simeq 1/137$ , where  $\alpha_{em}$  is finite structure constant in electron length scale and  $\hbar_0$  is the standard value of Planck constant.
2. The quantization of Planck constants makes the condition highly non-trivial. The most general quantization of  $r$  is as rationals but there are good arguments favoring the quantization as integers corresponding to the allowance of only singular coverings of CD andn  $CP_2$ . The point is that in this case a given value of Planck constant corresponds to a finite number pages of the “Big Book”. The quantization of the Planck constant implies a further quantization of  $K$  and would suggest that  $K$  scales as  $1/r$  unless the spectrum of values of  $Q_{em}$  and  $Q_Z$  allowed by the quantization condition scales as  $r$ . This is quite possible and the interpretation would be that each of the  $r$  sheets of the covering carries (possibly same) elementary charge. Kind of discrete variant of a full Fermi sphere would be in question. The interpretation in terms of anyonic phases [K18] supports this interpretation.
3. The identification of  $J$  as a counterpart of  $eB/\hbar$  means that Kähler action and thus also Kähler function is proportional to  $1/\alpha_K$  and therefore to  $\hbar$ . This implies that for large values of  $\hbar$  Kähler coupling strength  $g_K^2/4\pi$  becomes very small and large fluctuations are suppressed in the functional integral. The basic motivation for introducing the hierarchy of Planck constants was indeed that the scaling  $\alpha \rightarrow \alpha/r$  allows to achieve the convergence of perturbation theory: Nature itself would solve the problems of the theoretician. This of course does not mean that the physical states would remain as such and the replacement of single particles with anyonic states in order to satisfy the condition for  $K$  would realize this concretely.

4. The condition  $K = g_K^2/\hbar$  implies that the Kähler magnetic charge is always accompanied by Kähler electric charge. A more general condition would read as

$$K = n \times \frac{g_K^2}{\hbar}, n \in Z . \quad (2.8)$$

This would apply in the case of cosmic strings and would allow vanishing Kähler charge possible when the partonic 2-surface has opposite fermion and anti-fermion numbers (for both leptons and quarks) so that Kähler electric charge should vanish. For instance, for neutrinos the vanishing of electric charge strongly suggests  $n = 0$  besides the condition that abelian  $Z^0$  flux contributing to em charge vanishes.

It took a year to realize that this value of  $K$  is natural at the Minkowskian side of the wormhole throat. At the Euclidian side much more natural condition is

$$K = \frac{1}{\hbar \bar{a} r} . \quad (2.9)$$

In fact, the self-duality of  $CP_2$  Kähler form favours this boundary condition at the Euclidian side of the wormhole throat. Also the fact that one cannot distinguish between electric and magnetic charges in Euclidian region since all charges are magnetic can be used to argue in favor of this form. The same constraint arises from the condition that the action for  $CP_2$  type vacuum extremal has the value required by the argument leading to a prediction for gravitational constant in terms of the square of  $CP_2$  radius and  $\alpha_K$  the effective replacement  $g_K^2 \rightarrow 1$  would spoil the argument.

The boundary condition  $J_E = J_B$  for the electric and magnetic parts of Kähler form at the Euclidian side of the wormhole throat inspires the question whether all Euclidian regions could be self-dual so that the density of Kähler action would be just the instanton density. Self-duality follows if the deformation of the metric induced by the deformation of the canonically imbedded  $CP_2$  is such that in  $CP_2$  coordinates for the Euclidian region the tensor  $(g^{\alpha\beta} g^{\mu\nu} - g^{\alpha\nu} g^{\mu\beta})/\sqrt{g}$  remains invariant. This is certainly the case for  $CP_2$  type vacuum extremals since by the light-likeness of  $M^4$  projection the metric remains invariant. Also conformal scalings of the induced metric would satisfy this condition. Conformal scaling is not consistent with the degeneracy of the 4-metric at the wormhole.

#### 2.1.4 Reduction of the quantization of Kähler electric charge to that of electromagnetic charge

The best manner to learn more is to challenge the form of the weak electric-magnetic duality based on the induced Kähler form.

1. Physically it would seem more sensible to pose the duality on electromagnetic charge rather than Kähler charge. This would replace induced Kähler form with electromagnetic field, which is a linear combination of induced Kähler field and classical  $Z^0$  field

$$\begin{aligned} \gamma &= 3J - \sin^2 \theta_W R_{03} , \\ Z^0 &= 2R_{03} . \end{aligned} \quad (2.10)$$

Here  $Z_0 = 2R_{03}$  is the appropriate component of  $CP_2$  curvature form [L1]. For a vanishing Weinberg angle the condition reduces to that for Kähler form.

2. For the Euclidian space-time regions having interpretation as lines of generalized Feynman diagrams Weinberg angle should be non-vanishing. In Minkowskian regions Weinberg angle could however vanish. If so, the condition guaranteeing that electromagnetic charge of the partonic 2-surfaces equals to the above condition stating that the em charge assignable to the fermion content of the partonic 2-surfaces reduces to the classical Kähler electric flux at the Minkowskian side of the wormhole throat. One can argue that Weinberg angle must increase smoothly from a vanishing value at both sides of wormhole throat to its value in the deep interior of the Euclidian region.



3. The vanishing of the Weinberg angle in Minkowskian regions conforms with the physical intuition. Above elementary particle length scales one sees only the classical electric field reducing to the induced Kähler form and classical  $Z^0$  fields and color gauge fields are effectively absent. Only in phases with a large value of Planck constant classical  $Z^0$  field and other classical weak fields and color gauge field could make themselves visible. Cell membrane could be one such system [K20]. This conforms with the general picture about color confinement and weak massivation.

The GRT limit of TGD suggests a further reason for why Weinberg angle should vanish in Minkowskian regions.

1. The value of the Kähler coupling strength must be very near to the value of the fine structure constant in electron length scale and these constants can be assumed to be equal.
2. GRT limit of TGD with space-time surfaces replaced with abstract 4-geometries would naturally correspond to Einstein-Maxwell theory with cosmological constant which is non-vanishing only in Euclidian regions of space-time so that both Reissner-Nordström metric and  $CP_2$  are allowed as simplest possible solutions of field equations [K24]. The extremely small value of the observed cosmological constant needed in GRT type cosmology could be equal to the large cosmological constant associated with  $CP_2$  metric multiplied with the 3-volume fraction of Euclidian regions.
3. Also at GRT limit quantum theory would reduce to almost topological QFT since Einstein-Maxwell action reduces to 3-D term by field equations implying the vanishing of the Maxwell current and of the curvature scalar in Minkowskian regions and curvature scalar + cosmological constant term in Euclidian regions. The weak form of electric-magnetic duality would guarantee also now the preferred extremal property and prevent the reduction to a mere topological QFT.
4. GRT limit would make sense only for a vanishing Weinberg angle in Minkowskian regions. A non-vanishing Weinberg angle would make sense in the deep interior of the Euclidian regions where the approximation as a small deformation of  $CP_2$  makes sense.

The weak form of electric-magnetic duality has surprisingly strong implications for the basic view about quantum TGD as following considerations show.

## 2.2 Magnetic Confinement, The Short Range Of Weak Forces, And Color Confinement

The weak form of electric-magnetic duality has surprisingly strong implications if one combines it with some very general empirical facts such as the non-existence of magnetic monopole fields in macroscopic length scales.

### 2.2.1 How can one avoid macroscopic magnetic monopole fields?

Monopole fields are experimentally absent in length scales above order weak boson length scale and one should have a mechanism neutralizing the monopole charge. How electroweak interactions become short ranged in TGD framework is still a poorly understood problem. What suggests itself is the neutralization of the weak isospin above the intermediate gauge boson Compton length by neutral Higgs bosons. Could the two neutralization mechanisms be combined to single one?

1. In the case of fermions and their super partners the opposite magnetic monopole would be a wormhole throat. If the magnetically charged wormhole contact is electromagnetically neutral but has vectorial weak isospin neutralizing the weak vectorial isospin of the fermion only the electromagnetic charge of the fermion is visible on longer length scales. The distance of this wormhole throat from the fermionic one should be of the order weak boson Compton length. An interpretation as a bound state of fermion and a wormhole throat state with the quantum numbers of a neutral Higgs boson would therefore make sense. The neutralizing throat would have quantum numbers of  $X_{-1/2} = \nu_L \bar{\nu}_R$  or  $X_{1/2} = \bar{\nu}_L \nu_R$ .  $\nu_L \bar{\nu}_R$  would

not be neutral Higgs boson (which should correspond to a wormhole contact) but a super-partner of left-handed neutrino obtained by adding a right handed neutrino. This mechanism would apply separately to the fermionic and anti-fermionic throats of the gauge bosons and corresponding space-time sheets and leave only electromagnetic interaction as a long ranged interaction.

2. One can of course wonder what is the situation for the bosonic wormhole throats feeding gauge fluxes between space-time sheets. It would seem that these wormhole throats must always appear as pairs such that for the second member of the pair monopole charges and  $I_V^3$  cancel each other at both space-time sheets involved so that one obtains at both space-time sheets magnetic dipoles of size of weak boson Compton length. The proposed magnetic character of fundamental particles should become visible at TeV energies so that LHC might have surprises in store!

### 2.2.2 *Well-definedness of electromagnetic charge implies stringiness*

Well-definedness of electromagnetic charge at string world sheets carrying spinor modes is very natural constraint and not trivially satisfied because classical  $W$  boson fields are present. As a matter of fact, all weak fields should be effectively absent above weak scale. How this is possible classical weak fields identified as induced gauge fields are certainly present.

The condition that em charge is well defined for spinor modes implies that the space-time region in which spinor mode is non-vanishing has 2-D  $CP_2$  projection such that the induced  $W$  boson fields are vanishing. The vanishing of classical  $Z^0$  field can be posed as additional condition - at least in scales above weak scale. In the generic case this requires that the spinor mode is restricted to 2-D surface: string world sheet or possibly also partonic 2-surface. This implies that TGD reduces to string model in fermionic sector. Even for preferred extremals with 2-D projecting the modes are expected to allow restriction to 2-surfaces. This localization is possible only for Kähler-Dirac action.

A word of warning is however in order. The GRT limit or rather limit of TGD as Einstein Yang-Mills theory replaces the sheets of many-sheeted space-time with Minkowski space with effective metric obtained by summing to Minkowski metric the deviations of the induced metrics of space-time sheets from Minkowski metric. For gauge potentials a similar identification applies. YM-Einstein equations coupled with matter and with non-vanishing cosmological constant are expected on basis of Poincare invariance. One cannot exclude the possibility that the sums of weak gauge potentials from different space-time sheet tend to vanish above weak scale and that well-definedness of em charge at classical level follows from the effective absence of classical weak gauge fields.

### 2.2.3 *Magnetic confinement and color confinement*

Magnetic confinement generalizes also to the case of color interactions. One can consider also the situation in which the magnetic charges of quarks (more generally, of color excited leptons and quarks) do not vanish and they form color and magnetic singlets in the hadronic length scale. This would mean that magnetic charges of the state  $q_{\pm 1/2} - X_{\mp 1/2}$  representing the physical quark would not vanish and magnetic confinement would accompany also color confinement. This would explain why free quarks are not observed. To how degree then quark confinement corresponds to magnetic confinement is an interesting question.

For quark and antiquark of meson the magnetic charges of quark and antiquark would be opposite and meson would correspond to a Kähler magnetic flux so that a stringy view about meson emerges. For valence quarks of baryon the vanishing of the net magnetic charge takes place provided that the magnetic net charges are  $(\pm 2, \mp 1, \mp 1)$ . This brings in mind the spectrum of color hyper charges coming as  $(\pm 2, \mp 1, \mp 1)/3$  and one can indeed ask whether color hypercharge correlates with the Kähler magnetic charge. The geometric picture would be three strings connected to single vertex. Amusingly, the idea that color hypercharge could be proportional to color hyper charge popped up during the first year of TGD when I had not yet discovered  $CP_2$  and believed on  $M^4 \times S^2$ .

p-Adic length scale hypothesis and hierarchy of Planck constants defining a hierarchy of dark variants of particles suggest the existence of scaled up copies of QCD type physics and weak physics.

For p-adically scaled up variants the mass scales would be scaled by a power of  $\sqrt{2}$  in the most general case. The dark variants of the particle would have the same mass as the original one. In particular, Mersenne primes  $M_k = 2^k - 1$  and Gaussian Mersennes  $M_{G,k} = (1 + i)^k - 1$  has been proposed to define zoomed copies of these physics. At the level of magnetic confinement this would mean hierarchy of length scales for the magnetic confinement.

One particular proposal is that the Mersenne prime  $M_{89}$  should define a scaled up variant of the ordinary hadron physics with mass scaled up roughly by a factor  $2^{(107-89)/2} = 512$ . The size scale of color confinement for this physics would be same as the weal length scale. It would look more natural that the weak confinement for the quarks of  $M_{89}$  physics takes place in some shorter scale and  $M_{61}$  is the first Mersenne prime to be considered. The mass scale of  $M_{61}$  weak bosons would be by a factor  $2^{(89-61)/2} = 2^{14}$  higher and about  $1.6 \times 10^4$  TeV.  $M_{89}$  quarks would have virtually no weak interactions but would possess color interactions with weak confinement length scale reflecting themselves as new kind of jets at collisions above TeV energies.

In the biologically especially important length scale range 10 nm -2500 nm there are as many as four scaled up electron Compton lengths  $L_e(k) = \sqrt{5}L(k)$ : they are associated with Gaussian Mersennes  $M_{G,k}$ ,  $k = 151, 157, 163, 167$ . This would suggest that the existence of scaled up scales of magnetic-, weak- and color confinement. An especially interesting possibly testable prediction is the existence of magnetic monopole pairs with the size scale in this range. There are recent claims about experimental evidence for magnetic monopole pairs [D4] .

#### 2.2.4 Magnetic confinement and stringy picture in TGD sense

The connection between magnetic confinement and weak confinement is rather natural if one recalls that electric-magnetic duality in super-symmetric quantum field theories means that the descriptions in terms of particles and monopoles are in some sense dual descriptions. Fermions would be replaced by string like objects defined by the magnetic flux tubes and bosons as pairs of wormhole contacts would correspond to pairs of the flux tubes. Therefore the sharp distinction between gravitons and physical particles would disappear.

The reason why gravitons are necessarily stringy objects formed by a pair of wormhole contacts is that one cannot construct spin two objects using only single fermion states at wormhole throats. Of course, also super partners of these states with higher spin obtained by adding fermions and anti-fermions at the wormhole throat but these do not give rise to graviton like states [K10] . The upper and lower wormhole throat pairs would be quantum superpositions of fermion anti-fermion pairs with sum over all fermions. The reason is that otherwise one cannot realize graviton emission in terms of joining of the ends of light-like 3-surfaces together. Also now magnetic monopole charges are necessary but now there is no need to assign the entities  $X_{\pm}$  with gravitons.

Graviton string is characterized by some p-adic length scale and one can argue that below this length scale the charges of the fermions become visible. Mersenne hypothesis suggests that some Mersenne prime is in question. One proposal is that gravitonic size scale is given by electronic Mersenne prime  $M_{127}$ . It is however difficult to test whether graviton has a structure visible below this length scale.

What happens to the generalized Feynman diagrams is an interesting question. It is not at all clear how closely they relate to ordinary Feynman diagrams. All depends on what one is ready to assume about what happens in the vertices. One could of course hope that zero energy ontology could allow some very simple description allowing perhaps to get rid of the problematic aspects of Feynman diagrams.

1. Consider first the recent view about generalized Feynman diagrams which relies ZEO. A highly attractive assumption is that the particles appearing at wormhole throats are on mass shell particles. For incoming and outgoing elementary bosons and their super partners they would be positive it resp. negative energy states with parallel on mass shell momenta. For virtual bosons they the wormhole throats would have opposite sign of energy and the sum of on mass shell states would give virtual net momenta. This would make possible twistor description of virtual particles allowing only massless particles (in 4-D sense usually and in 8-D sense in TGD framework). The notion of virtual fermion makes sense only if one assumes in the interaction region a topological condensation creating another wormhole throat having no fermionic quantum numbers.

2. The addition of the particles  $X^\pm$  replaces generalized Feynman diagrams with the analogs of stringy diagrams with lines replaced by pairs of lines corresponding to fermion and  $X_{\pm 1/2}$ . The members of these pairs would correspond to 3-D light-like surfaces glued together at the vertices of generalized Feynman diagrams. The analog of 3-vertex would not be splitting of the string to form shorter strings but the replication of the entire string to form two strings with same length or fusion of two strings to single string along all their points rather than along ends to form a longer string. It is not clear whether the duality symmetry of stringy diagrams can hold true for the TGD variants of stringy diagrams.
3. How should one describe the bound state formed by the fermion and  $X^\pm$ ? Should one describe the state as superposition of non-parallel on mass shell states so that the composite state would be automatically massive? The description as superposition of on mass shell states does not conform with the idea that bound state formation requires binding energy. In TGD framework the notion of negentropic entanglement has been suggested to make possible the analogs of bound states consisting of on mass shell states so that the binding energy is zero [K15]. If this kind of states are in question the description of virtual states in terms of on mass shell states is not lost. Of course, one cannot exclude the possibility that there is infinite number of this kind of states serving as analogs for the excitations of string like object.
4. What happens to the states formed by fermions and  $X_{\pm 1/2}$  in the internal lines of the Feynman diagram? Twistor philosophy suggests that only the higher on mass shell excitations are possible. If this picture is correct, the situation would not change in an essential manner from the earlier one.

The highly non-trivial prediction of the magnetic confinement is that elementary particles should have stringy character in electro-weak length scales and could behaving to become manifest at LHC energies. This adds one further item to the list of non-trivial predictions of TGD about physics at LHC energies [K16].

### **3 Dark Matter Hierarchy, Genetic Machinery, And The Un-Reasonable Selectivity Of Bio-Catalysis**

One of the most fascinating outcomes of ideas related to the dark matter hierarchy is the notion of inherently dark fractional atom (molecule) generalizing the notion of Bose-Einstein condensate to the fermionic case. These notions might provide an elegant manner to understand the mysteries of DNA replication, transcription, and translation, and more generally, the incredible selectivity of bio-catalysis.

As often, the original idea was not quite correct. I spoke about  $N$ -atoms rather than fractional atoms. In particular, the mass of  $N$ -molecule was  $N$  times larger than that of the ordinary molecule apart from corrections from binding energy. The more precise view about dark matter hierarchy led to the realization that fractionization of all quantum numbers occurs. In the most general case one can have fractional particles with particle number  $n = k/r$ ,  $k = 1, \dots, r$ ,  $r = \frac{\hbar}{\hbar_0}$ . This leaves the model essentially as such at formal level. The model is however much more realistic than the original one since fractional atoms have mass which is never larger than that of ordinary atom and also conforms with the recent view about the origin of the hierarchy of Planck constants.

#### **3.1 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.

The rules are very simple when one takes the singular coverings assigned to the many-valuedness of the time-derivatives of imbedding space coordinates as functions of canonical momentum densities as a starting point.

1. The mass and charge of electron are fractionized as is also the reduced mass in Schrödinger equation. This implies the replacements  $e \rightarrow e/r$ ,  $m \rightarrow m/r$ , and  $\hbar \rightarrow r\hbar_0$ ,  $r = n_a n_b$ , in the general formula for the binding energy assigned with single sheet of the covering. If maximal number  $n_a n_b$  are present corresponding to a full “Fermi sphere”, the total binding energy is  $r$  times the binding energy associated with single sheet.
2. In the case of hydrogen atom the proportionality  $E \propto m/\hbar^2$  implies that the binding energy for single sheet of the covering scales as  $E \rightarrow E/(n_a n_b)^3$  and maximal binding energy scales as  $E \rightarrow E/(n_a n_b)^2$ . This conforms with the naive guess. For high values of the nuclear charge  $Z$  it can happen that the binding energy is larger than the rest mass and fractionization might take place when binding energy is above critical fraction of the rest mass.
3. In the case of cyclotron energies one must decide what happens to the magnetic flux. Magnetic flux quantization states that the flux is proportional to  $\hbar$  for each sheet separately. Hence one has  $\Phi \rightarrow r\Phi$  for each sheet and the total flux scales as  $r^2$ . Since the dimensions of the flux quantum are scaled up by  $r$  the natural scaling of the size of flux quantum is by  $r^2$ . Therefore the quantization of the magnetic flux requires the scaling  $B \rightarrow B/r$ . The cyclotron energy for single sheet satisfies  $E \propto \hbar q B/m$  and since both mass  $m$  and charge  $q$  become fractional, the energy  $E$  for single sheet remains invariant whereas total cyclotron energy is scaled up by  $r$  in accordance with the original guess and the assumption used in applications.
4. Dark cyclotron states are expected to be stable up to temperatures which are  $r$  times higher than for ordinary cyclotron states. The states of dark hydrogen atoms and its generalizations are expected to be stable at temperatures scaled down by  $1/r^2$  in the first approximation.
5. Similar arguments allow to deduce the values of binding energies in the general case once the formula of the binding energy given by standard quantum theory is known.

The most general option allows fractional atoms with proton and electron numbers varying from  $1/r$  to 1. One can imagine also the possibility of fractional molecules. The analogs of chemical bonds between fractional hydrogen atoms with  $N - k$  and  $k$  fractional electrons and protons can be considered and would give rise to a full shell of fractional electrons possessing an exceptional stability. These states would have proton and electron numbers equal to one.

Catalytic sites are one possible candidate for fractal electrons and catalyst activity might be perhaps understood as a strong tendency of fractal electron and its conjugate to fuse to form an ordinary electron.

### 3.1.1 Connection with quantum groups?

The phase  $q = \exp(i2\pi/r)$  brings unavoidably in mind the phases defining quantum groups and playing also a key role in the model of topological quantum computation [K26]. Quantum groups indeed emerge from the spinor structure in the “world of classical worlds” realized as the space of 3-surfaces in  $M^4 \times CP_2$  and being closely related to von Neumann algebras known as hyper-finite factors of type  $II_1$  [K27].

Only singular coverings are allowed if the hierarchy of Planck constants and corresponding hierarchy of singular coverings follows from the basic TGD. If the integer  $n$  characterizing the quantum phase allows identification with  $r = \hbar/\hbar_0$ , living matter could be perhaps understood in terms of quantum deformations of the ordinary matter, which would be characterized by the quantum phases  $q = \exp(i2\pi/r)$ . Hence quantum groups, which have for long time suspected to have significance in elementary particle physics, might relate to the mystery of living matter and predict an entire hierarchy of new forms of matter.

**3.1.2 How to distinguish between fractional particles and ordinary particles?**

The unavoidable question is whether bio-molecules in vivo could involve actually fractional atoms molecules as their building blocks. This raises a series of related questions.

1. Could it be that we can observe only the fusion of of dark fractional fold molecules to ordinary molecules or its reversal? Is the behavior of matter matter in vivo dictated by the dark matter commentn and of matter in vitro by ordinary matter? Could just the act of observing the matter in vivo in the sense of existing science make it ordinary dead matter?
2. If fractional atoms and molecules correspond to the maximum number of fractional quanta their masses are same as for ordinary atoms and molecules and only the different binding energy photon spectrum distinguishes between them. Situation changes all fractional states are possible and one obtains scaled down spectrum as a unique signature.
3. The fusion of fractional molecules to ordinary molecules in principle allows to conclude that fractional molecule was present. Could this process mean just the replacement of DNA in vivo with DNA in vitro?

**3.2 Spontaneous Decay And Completion Of Dark Fractional Atoms As A Basic Mechanisms Of Bio-Chemistry?**

The replication of DNA has remained for me a deep mystery and I dare to doubt that the reductionistic belief that this miraculous process is well-understood involves self deceptive elements. Of course the problem is much more general: DNA replication is only a single very representative example of the miracles of un-reasonable selectivity of the bio-catalysis. I take this fact as a justification for some free imagination inspired by the notion of dark fractional molecule.

**3.2.1 Dark fermionic molecules can replicate via decay and spontaneous completion**

Unit particle number for fractional atom or molecule means that the analog of closed electronic shell are in question so that the state is especially stable. Note that the analogy with full Fermi electronic sphere makes also sense. These atoms or molecules could decay to fractional atoms or molecules. with fractional particle numbers  $k/r$  and  $(r - k)/r$ .

Suppose that a fractional molecule with unit particle number decays into  $k/r$ -molecule and  $(r - k)/r$ -molecule. If  $r$  is even it is possible to have  $k = r - k = r/2$  and the situation is especially symmetric. If fermionic  $k/r < 1$  fractional atoms or molecules are present, one can imagine that they tend to be completed to full molecules spontaneously. Thus spontaneous decay and completion would favor the spontaneous replication (or rather fractionization) and dark molecules could be ideal replicators (fractionizators) The idea that the mechanisms of spontaneous decay and completion of dark fractional particles somehow lurk behind DNA replication and various high precision bio-catalytic processes is rather attractive.

**3.2.2 Reduction of lock and key mechanism to spontaneous completion**

DNA replication and molecular recognition by the lock and key mechanism are the two mysterious processes of molecular biology. As a matter fact, DNA replication reduces to spontaneous opening of DNA double strand and to the lock and key mechanism so that it could be enough to understand the opening of double strand in terms of spontaneous decay and lock and key mechanism in terms of spontaneous completion of fractional particle (-atom or -molecule).

Consider bio-molecules which fit like a lock and key. Suppose that they are accompanied by dark fractional atoms or molecules, to be called dark fractional particles in sequel, such that one has  $k_1 + k_2 = r$  so that in the formation of bound state dark molecules combine to form  $r$ -molecule analogous to a full fermionic shell or full Fermi sea. This is expected to enhance the stability of this particular molecular complex and prefer it amongst generic combinations.

For instance, this mechanism would make it possible for nucleotide and its conjugate, DNA and mRNA molecule, and tRNA molecule and corresponding amino-acid to recognize each other. Spontaneous completion would allow to realize also the associations characterizing the genetic code

as a map from RNAs to subset of RNAs and associations of this subset of RNAs with amino-acids (assuming that genetic code has evolved from RNA  $\rightarrow$  RNA code as suggested in this chapter).

As such this mechanism allows a rather limited number of different lock and key combinations unless  $r$  is very large. There is however a simple generalization allowing to increase the representative power so that lock and key mechanism becomes analogous to a password used in computers. The molecule playing the role of lock *resp.* molecule would be characterized by a set of  $n$  fractional particles with  $k_1 \in \{k_{1,1}, \dots, k_{1,n}\}$  *resp.*  $k_2 \in \{k_{2,1} = r - k_{1,1}, \dots, k_{2,n} = r - k_{1,n}\}$ . The molecules with conjugate names would fit optimally together. Fractional molecules or fractional electrons or atoms appearing as their building blocks would be like letters of a text characterizing the name of the molecule.

The mechanism generalizes also to the case of  $n > 2$  reacting molecules. The molecular complex would be defined by a partition of  $n$  copies of integer  $r$  to a sum of  $m$  integers  $k_{k,i}$ :  $\sum_i k_{k,i} = r$ .

This mechanism could provide a universal explanation for the miraculous selectivity of catalysts and this selectivity would have practically nothing to do with ordinary chemistry but would correspond to a new level of physics at which symbolic processes and representations based on dark fractional particles emerge.

### 3.2.3 Connection with the number theoretic model of genetic code?

The emergence of partitions of integers in the labelling of molecules by fractional particles suggests a connection with the number theoretical model of genetic code [K5], where DNA triplets are characterized by integers  $n \in \{0, \dots, 63\}$  and amino-acids by integers 0, 1 and 18 primes  $p < 64$ . For instance, one can imagine that the integer  $n$  means that DNA triplet is labelled by  $n/r$ -particle.  $r = 64$  would be the obvious candidate for  $r$  and conjugate DNA triplet would naturally have  $n_c = 64 - n$ .

The model relies on number-theoretic thermodynamics for the partitions of  $n$  to a sum of integers and genetic code is fixed by the minimization of number theoretic entropy which can be also negative and has thus interpretation as information. Perhaps these partitions could correspond to states resulting in some kind of decays of  $n$ -fermion to  $n_k/r$ -fermions with  $\sum_{k=1}^r n_k = n$ . The  $n_k/r$ -fermions should however not correspond to separate particles but something different. A possible interpretation is that partition corresponds to a state in which  $n_1/r$  particle is topologically condensed at  $n_2/r \geq n_1/r$  particle topologically condensed...at  $n_k/r \geq n_{k-1}/r$ -particle. This would also automatically define a preferred ordering of the integers  $n_i$  in the partition.

An entire ensemble of labels would be present and depending on the situation codon could be labelled not only by  $n/r$ -particle but by any partition  $n = \sum_{i=1}^k n_i$  corresponding to the state resulting in the decay of  $n/r$ -particle to  $k$  fractional particles.

### 3.2.4 Reduction of DNA replication to a spontaneous decay of $r$ -particle

DNA replication could be induced by a spontaneous decay of  $r$ -particle inducing the instability of the double strand leading to a spontaneous completion of the component strands.

Strand and conjugate strand would be characterized by  $k_1/r$ -particle and  $(r - k_1)/r$ -particle, which combine to form  $r$ -particle as the double strand is formed. The opening of the double strand is induced by the decay of  $r$ -particle to  $k_1/r$ - and  $(r - k_1)/r$ -particles accompanying strand and its conjugate and after this both strands would complete themselves to double strands by the completion to  $r$ -particle.

It would be basically the stability of fractional particle which would make DNA double strand stable. Usually the formation of hydrogen bonds between strands and more generally, between the atoms of stable bio-molecule, is believed to explain the stability. Since the notion of hydrogen bond is somewhat phenomenological, one cannot exclude the possibility that these two mechanisms might be closely related to each other. I have already earlier considered the possibility that hydrogen bond might involve dark protons [K7]: this hypothesis was inspired by the finding that there seems to exist two kinds of hydrogen bonds [D7].

The reader has probably already noticed that the participating fractional molecules in the model of lock and key mechanism are like sexual partners, and if already molecules are conscious entities as TGD inspired theory of consciousness strongly suggests, one might perhaps see the formation of entangled bound states with positive number theoretic entanglement entropy accompanied by

molecular experience of one-ness as molecular sex. Even more, the replication of DNA brings in also divorce and process of finding of new companions!

### 3.3 The New View About Hydrogen Bond And Water

Concretization of the above scenario leads to a new view about hydrogen bond and the role of water in bio-catalysis.

#### 3.3.1 What the fractional particles labelling bio-molecules could be?

What the dark fractional particles defining the letters for the names of various bio-molecules could be? Dark fractional hydrogen atoms are the lightest candidates for the names of bio-molecules. The fusion could give rise to the hydrogen atom appearing in hydrogen bond. One could say the fractional hydrogen atoms belong to the molecules between which the hydrogen bond is formed. In absence of bond the fractional atoms would define active catalyst sites. This mechanism would also conform with the belief that hydrogen bonds guarantee the stability of bio-molecules.

This idea is not a mere speculation. The first experimental support for the notion of dark matter [K7] came from the experimental finding that water looks in atto-second time scale from the point of view of neutron diffraction and electron scattering chemically like  $H_{1.5}O$ : as if one fourth of protons are dark [D8, D6, D10, D3]. Dark protons would be identifiable as fractional protons. Of course, also dark hydrogen atoms can be considered.

One can imagine also a second option. The model for [I1] [K12] leads to a rather concrete view about how magnetic body controls biological body and receives sensory input from it. The model relies on the idea that dark water molecule clusters and perhaps also dark exotically ionized super-nuclei formed as linear closed strings of dark protons [K7] perform this mimicry. Dark proton super-nuclei are ideal for mimicking the cyclotron frequencies of ordinary atoms condensed to dark magnetic flux quanta. Of course, also partially ionized hydrogen fractional ions could perform the cyclotron mimicry of molecules with the same accuracy.

One can consider the possibility fractional molecules/atoms correspond to exotic atoms formed by electrons bound to exotically ionized dark super-nuclei: the sizes of these nuclei are however above atomic size scale so that dark electrons would move in a harmonic oscillator potential rather than Coulombic potential and form states analogous to atomic nuclei. The prediction would be the existence of magic electron numbers [K7]. Amazingly, there is strong experimental evidence for the existence of this kind of many-electron states. Even more, these states are able to mimic the chemistry of ordinary atoms [D9, D2, D1]. The formation of hydrogen bonds between catalyst and substrate could be the correlate for the fusion of fractional hydrogen atoms.

If the fusion process gives rise 1/1-hydrogen, its spontaneous decay to ordinary hydrogen would liberate the difference of binding energies as metabolic energy helping to overcome the energy barrier for the reaction. The liberated energy would be rather large and correspond 3.4 eV UV photon even for  $r = 2$  which suggests that it does not relate with standard metabolism. For larger values of  $r$  the liberated energy rapidly approaches to the ground state energy of hydrogen. Note that the binding energy of ordinary hydrogen atom in state  $n = r$  has in the lowest order approximation same energy as the ground state of dark hydrogen atom for  $\hbar/\hbar_0 = r$  so that one can consider the possibility of a resonant coupling of these states.

Fractional protons and electrons have effective charge  $\pm ke/r$  so that the binding regions of catalysts and reacting molecules could carry effective fractional surface charge.

This might relate in an interesting manner to the problem of how poly-electrolytes can be stable (I am grateful for Dale Trenary for pointing me the problem and for interesting discussions). For instance, DNA carries a charge of -2 units per nucleotide due to the phosphate backbone. The models trying to explain the stability involve effective binding of counter ions to the polyelectrolyte so that the resulting system has a lower charge density. The simulations of DNA condensation by Stevens [I6] however predict that counter ion charge should satisfy  $z > 2$  in the case of DNA. The problem is of course that protons with  $z = 1$  are the natural counter ions. The positive surface charge defined by the fractional protons attached to the nucleotides of DNA strand could explain the stability.



### 3.3.2 The hydrogen atoms in hydrogen bonds as fractional hydrogen atoms and $H_{1.5}O$ formula for water

The simplest assumption is that the hydrogens associated with hydrogen bonds are actually associated with  $1/1$  type dark hydrogen atoms. This hypothesis has interesting implications and could explain the formula  $H_{1.5}O$  for water in atto-second time scales suggested by neutron diffraction and electron scattering [D8, D6, D10, D3].

The formation of hydrogen bond would correspond to a fusion of name and conjugate name between  $H_{k/r}$ -O-H atom and its conjugate  $H_{(r-k)/r}$ -O-H atom. The resulting pairs would obey the chemical formula  $H_3-O_2$ . Hence the formation of hydrogen bonds would predict the  $H_{1.5}O$  formula suggested by neutron diffraction and electron scattering in atto-second time scale. This holds true only if one has complete pairing by hydrogen bonds. A more plausible explanation is that just the presence of fractional hydrogens implies the effect. Furthermore, the fraction of dark protons can depend on temperature.

### 3.3.3 The roles of water and ordered water in catalysis

The new view about hydrogen bond allows to understand the role of water in biology at qualitative level. For instance, one can

1. tentatively identify “ordered water” as a phase in which all  $H_{k/r}$  atoms and their conjugates have combined to  $H_{1/1}$  atoms,
2. understand why (or perhaps it is better to say “predict that” ) water containing  $H_{k/r}$  atoms acts as a catalytic poison so that the binding sites of catalysts and reactants must be isolated from water unless the water is ordered,
3. justify the belief that gel phase involving ordered water is necessary for biological information processing,
4. understand why hydration causes hydrolysis,
5. understand the instability of DNA against decay to RNA outside nucleus.

A more more detailed sketch looks like following.

1. Suppose that at least part of water molecules appear in form  $H_{k/r}$ -OH and  $H_{(r-k)/r}$ -O-H. These molecules and the the molecule  $H_{1/1}$ -OH<sub>2</sub> formed in their fusion has much smaller binding energy than ordinary water molecule and is expected to be unstable against transition to  $H_3O$ . This would suggest that the feed of metabolic energy is needed to generate the dark hydrogen atoms.

Fractional dark water molecules can join pairwise to form  $H-O-(H_{1/1})-O-H \equiv H_3O_2$  with  $H_{1/1}$ -atoms replacing hydrogen in hydrogen bond. Also  $H_{k_1/r}$ -O- $H_{k_2/r}$  molecules are possible and could form closed strings obeying the chemical formula  $O_n(H_{1/1})_n$ . Also open strings with H-O: s at ends are possible. This phase of water might allow identification as “ordered water” believed to be associated with gel phase and be crucial for quantal information processing inside cell. Liquid crystal phase of water could correspond to a bundle of open vertical segments  $H-O_n(H_{1/1})_{n-2}-H$  forming a 2-dimensional liquid (vertical freezing).

2. Exotic water molecules could spoil the action of both catalyst and reactant molecules by attaching to the “letters” in the name of catalyst or reactant so that the letters are not visible and catalyst and reactant cannot recognize each other anymore. Hence binding sites of catalyst and reactant must be isolated from water containing fractional water molecules. This is what Sidorova and Rau [I7] suggest on basis of comparison of specific and non-specific catalysts: non-specific catalysts contain water in an isolated binding volume whereas for specific catalysts this volume is empty. An alternative mechanism hindering water molecules to attach to “letters” is that water is “ordered water” with no fractional water molecules present.
3. DNA is known to be stable against decay to RNA via hydration inside the cell but not outside. Hydration could correspond to the joining of fractional water to sites of DNA transforming it to RNA. Inside nucleus this cannot occur if water is in ordered water phase permanently.

### 3.3.4 How the first self-replicators emerged?

The identification of the first self replicator can be seen as perhaps the most fascinating and challenging problem faced by the pre-biotic model builders. Self replicator is by definition an entity which catalyzes its own replication. The analogy with the self-referential statement appearing in Gödel's theorem obvious.

In TGD framework self replication would reduce to a spontaneous decay of  $H_{1/1}$ -atom to  $H_{k/r}$ - and  $H_{(r-k)/r}$ -atoms and their subsequent completion to  $H_{1/1}$ -atoms

The picture about emergence of self-replicators would be roughly following.

1. The first self-replicating entities would have been plasmoids [I5] generating  $H_{1/1}$  atoms whose presence would have made possible the emergence of the first molecular self replicators. The generation of  $H_{1/1}$  atoms requires metabolic energy feed. In the first approximation the decay of  $H_{1,1}$  to fractional hydrogen atoms does not liberate nor require energy.
2.  $H_{k/r}$  atoms would have replaced some ordinary  $H$ -atoms in some negatively charged molecules  $M_i$  (perhaps MXTP,  $X = A, U, C, G$ ) leading to a spontaneous emergence of linear negatively charged polymers consisting of  $M_i$ . One can imagine a coding in which each  $X$  corresponds to fixed value of  $k$  or collection of the (2 hydrogen bonds or 3 hydrogen bonds depending on  $X$ ). This would make the attachment of  $X$  and its conjugate to form a hydrogen bond a highly favored process.
3.  $H_{k/r}$  atoms would have taken also the role of active binding sites. In ordered water conjugate molecules  $M_{c,i}$  having  $H_{(r-k)/r}$  atoms as labels would have had high probability to attach to the polymers made of  $M_i$ .
4. RNA molecules are good candidates for self-replicators in the presence of ordered water. The phase transition from ordinary to ordered water (which would have developed later to sol-gel phase transition) would have been an essential element of replication.

### 3.3.5 The role of water in chiral selection

In the latest New Scientist (when I am writing this) there was a news telling that chiral selection occurs in water but not in heavy water [C8]. The L form of amino-acid glutamate is more stable than R in ordinary but not so in heavy water so that water environment must be responsible for the chirality selection of bio-molecules. The proposed explanation for the finding, whose importance cannot be over-estimated, was following.

1. Water molecules have two forms: orto- and para, depending on whether the nuclear spins of protons are parallel or opposite. Deuterium nuclei are spinless so that heavy water has only single form. In thermal equilibrium the fraction of orto water is 3/4 and para water 1/4.
2. Ortho-water is magnetic and if L form of amino-acid is slightly more magnetic than R, chirality selection can be understood as result of the magnetic interaction with water.

One can of course wonder how extremely short ranged weak interactions could produce strong enough effect on the magnetic moment. The situation is not made easier by the fact that magnetic interaction energies are inherently very weak and deep below the thermal threshold.

It is interesting to find whether these findings could be explained by and allow a more detailed formulation of the TGD based model for water based on the notion of fractional hydrogen atom, the new view about hydrogen bond, and the notion of dark protonic strings forming atomic sized super-nuclei carrying exotic weak charges.

1. Dark matter brings in long ranged exotic weak interactions which can produce large parity breaking effects in atomic and even longer length scales. The long ranged parity breaking weak interactions of the dark protonic super nuclei assignable to amino-acids and water could explain the chiral selection.

2. The magnetic interaction energy is scaled up by  $r$ , so that magnetic interactions could indeed play a key role. Ordinary classical magnetic fields are in TGD framework always accompanied by  $Z^0$  magnetic fields. If amino-acids possess exotic em charge implying also exotic weak charge, one can understand the chiral breaking as being induced by the  $Z^0$  magnetic interaction of aminocids with the dark magnetic fields generated by water molecules or their clusters possessing a net magnetic moment. In heavy water these fields would be absent so that the experimental findings could be understood.
3. The experimental evidence that water behaves as  $H_{1.5}O$  in atto-second time scales means that 1/4: th of protons of water are effectively dark. The notion of fractional hydrogen atom leads to a model of hydrogen bond predicting correctly  $H_{1.5}O$  formula and the dropping of 1/4: th of protons at larger possibly dark space-time sheets. The model also predicts that the mass of  $H - O - H_r - O - H \equiv 2H_{1.5}O$  hydrogen bonded pairs is very near to the mass of 2 water molecules since there are  $r \simeq m_p/m_e$  electrons involved. The paired molecules have three protons and non-vanishing net nuclear spin and thus generate a magnetic field and make hydrogen bonded water a magnetic system. The natural identification would be as dark magnetic field accompanied by  $Z^0$  magnetic field responsible for the chiral selection. In the case of  $D - O - D_r - O - D$  mass would be by about one proton mass  $m_p$  lower than mass of two  $D_2O$  molecules so that this D-bonded heavy water would look like  $D_{1.25}O$  as far as masses are considered and  $D_{1.5}O$  as far as neutron diffraction and electron scattering are considered. In this case no magnetic field is generated since the nuclear spin of  $D$  vanishes and no chiral breaking results. This picture explains the experimental findings. The model is not equivalent with the proposal of the experimentalists.
4. The model predicts that the protons liberated in the formation of hydrogen bonds drop to larger space-time sheets but does not specify their fate. A strong constraint comes from the requirement that the dropped particles have exotic weak charges acting as sources of the geometrically unavoidable classical  $Z^0$  magnetic field at dark space-time sheets causing the large parity breaking. This constraint is satisfied if the protons form super-nuclei (scaled up variants of nuclei) consisting of protonic strings connected by color bonds involving exotic quark and antiquark at its ends and some of these bonds are charged (of type  $u\bar{d}$  or  $d\bar{u}$ : this could also generate the em charge needed to make the protonic string stable.

## 4 TGD Based Model For Qualia And Sensory Receptors

The identification of quantum number increments in quantum jump for a subsystem representing sub-self and the capacitor model of sensory receptor are already more than decade old ideas.

The concrete realization of this vision is based on several ideas that I have developed during last five years.

1. The vision about dark matter as a hierarchy of phases partially labeled by the value of Planck constant led to the model of DNA as topological quantum computer [K8]. In this model magnetic flux tubes connecting DNA nucleotides with the lipids of the cell membrane define strands of the braids defining topological quantum computations. The braid strand corresponds to so called wormhole flux tube and has quark and antiquark at its ends.  $u$  and  $d$  quarks and their antiquarks code for four DNA nucleotides in this model.
2. Zero energy ontology assigns to elementary particles so called causal diamonds (CDs). For  $u$  and  $d$  quarks and electron these time scales are (6.5, .78, 100) ms respectively, and correspond to fundamental biorhythms. Electron time scale corresponds to 10 Hz fundamental biorhythm defining also the fundamental frequency of speech organs, .78 ms to kHz cortical synchrony [J7], and 160 Hz to cerebellar synchrony [J6]. Elementary particles therefore seem to be directly associated with neural activity, language, and presumably also hearing. One outcome was the modification of the earlier model of memetic code involving the notion of cognitive neutrino pair by replacing the sequence of cognitive neutrino pairs with that of quark sub-CDs within electron CD. Nerve pulses could induce the magnetization direction of quark coding for bit but there are also other possibilities. The detailed implications for the model of nerve pulse [K20] remain to be disentangled.

3. The understanding of the Negentropy Maximization Principle [K15] and the role of negentropic entanglement in living matter together with the vision about life as something in the intersection of real and p-adic worlds was a dramatic step forward. In particular, space-like and time-like negentropic entanglement (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig. ??** in the appendix of this book) become basic aspects of conscious intelligence and are expected to be especially important for understanding the difference between speech and music.
4. One of the basic challenge has been to construct a quantitative model for cell membrane.
  - (a) The first model was based on the assumption that long range weak forces however play a key role [K3]. They are made possible by the exotic ground state represented as almost vacuum extremal of Kähler action for which classical em and  $Z^0$  fields are proportional to each other whereas for the standard ground state classical  $Z^0$  fields are very weak. Neutrinos are present but it seems that they do not define cognitive or Boolean representations in the time scales characterizing neural activity. Electrons and quarks for which the time scales of causal diamonds correspond to fundamental biorhythms - one of the key observations during last years- take this role. The essential element is that the energies of the Josephson photons are in visible range. This would explain bio-photons and even why the frequencies assignable to visual receptors. The problem is that Weinberg angle must be assumed to be much smaller in the near vacuum extremal phase than in standard model.
  - (b) Second model is based on Gerald Pollack's findings about fourth phase of water and exclusion zones [I3]. These zones inspire a model for pre-biotic cells. The outcome is a modification of the simplest model of Josephson junction. Besides resting potential also the difference between cyclotron energies between the two sides of the membrane plays a key role. This model allows to understand what happens in metabolism in terms of a quantum model replacing the thermodynamical model for cell membrane with its quantal "square root" inspired by Zero Energy Ontology. The model allows also to understand bio-photons as decay products of dark photons.
  - (c) The success of the latter model does not of course mean that the weak forces could not be important in cell membrane scale and the realistic model could be a hybrid of these two models. The inclusion of  $Z^0$  contribution to the effective magnetic field could also to the fact that the endogenous magnetic field deduced from Blackman's experiments is  $B_{end} = 2B_E/5$  rather than  $B_E$  (Earth's magnetic field).

## 4.1 A General Model Of Qualia And Sensory Receptor

The identification of sensory qualia in terms of quantum number increments and geometric qualia representing geometric and kinematic information in terms of moduli of CD, the assignment of sensory qualia with the membrane of sensory receptor, and capacitor model of qualia are basic ideas behind the model. The communication of sensory data to magnetic body using Josephson photons is also a key aspect of the model.

### 4.1.1 A general model of qualia

It is good to start by summarizing the general vision about sensory qualia and geometric qualia in TGD Universe.

1. The basic assumption is that sensory qualia correspond to increments of various quantum numbers in quantum jump. Standard model quantum numbers- color quantum numbers, electromagnetic charge and weak isospin, and spin are the most obvious candidates. Also cyclotron transitions changing the integer characterizing cyclotron state could corresponds to some kind of quale- perhaps "a feeling of existence". This could make sense for the qualia of the magnetic body.
2. Geometric qualia could correspond to the increments of zero modes characterizing the induced  $CP_2$  Kähler form of the partonic 2-surface and of the moduli characterizing the causal

diamonds serving as geometric correlates of selves. This moduli space involves the position of CD and the relative position of tips as well as position in  $CP_2$  and relative position of two  $CP_2$  points assigned to the future and past boundaries of CD. There are good motivations for proposing that the relative positions are quantized. This gives as a special case the quantization of the scale of CD in powers of two. Position and orientation sense could represent this kind of qualia. Also kinematical qualia like sensation of acceleration could correspond to geometric qualia in generalized 4-D sense. For instance, the sensation about motion could be coded by Lorentz boosts of sub-CD representing mental image about the object.

3. One can in principle distinguish between qualia assignable to the biological body (sensory receptors in particular) and magnetic body. The basic question is whether sensory qualia can be assigned only with the sensory receptors or with sensory pathways or with both. Geometric qualia might be assignable to the magnetic body and could provide third person perspective as a geometric and kinematical map of the body and its state of motion represented using the moduli space assignable to causal diamonds (CD). This map could be provided also by the body in which case the magnetic body would only share various mental images. The simplest starting assumption consistent with neuro-science is that sensory qualia are assigned with the cell membrane of sensory receptor and perhaps also with the neurons receiving data from it carried by Josephson radiation coding for the qualia and possibly partially regenerating them if the receiving neuron has same value of membrane potential as the sensory receptor when active. Note that during nerve pulse also this values of membrane potential is achieved for some time.

#### 4.1.2 Could some sensory qualia correspond to the sensory qualia of the magnetic body?

Concerning the understanding of a detailed model for how sensory qualia are generated, the basic guideline comes from the notion of magnetic body and the idea that sensory data are communicated to the magnetic body as Josephson radiation associated with the cell membrane. This leaves two options: either the primary a sensory qualia are generated at the level of sensory receptor and the resulting mental images negentropically entangle with the “feeling of existence” type mental images at the magnetic body or they can be also generated at the level of the magnetic body by Josephson radiation -possibly as cyclotron transitions. The following arguments are to-be-or-not-to-be questions about whether the primary qualia must reside at the level of sensory receptors.

1. Cyclotron transitions for various cyclotron condensates of bosonic ions or Cooper pairs of fermionic ions or elementary particles are assigned with the motor actions of the magnetic body and Josephson frequencies with the communication of the sensory data. Therefore it would not be natural to assign qualia with cyclotron transitions. One the other hand, in zero energy ontology motor action can be regarded formally as a time reversed sensory perception, which suggests that cyclotron transitions correlated with the “feeling of existence” at magnetic body entangled with the sensory mental images. They could also code for the pitch of sound as will be found but this quale is strictly speaking also a geometric quale in the 4-D framework.
2. If Josephson radiation induces cyclotron transitions, the energy of Josephson radiation must correspond to that of cyclotron transition. This means very strong additional constraint not easy to satisfy except during nerve pulse when frequencies varying from about  $10^{14}$  Hz down to kHz range are emitted the system remains Josephson contact. Cyclotron frequencies are also rather low in general, which requires that the value of  $\hbar$  must be large in order to have cyclotron energy above the thermal threshold. This would however conform with the very beautiful dual interpretation of Josephson photons in terms of bio-photons and EEG. One expects that only high level qualia can correspond to a very large values of  $\hbar$  needed.

For the sake of completeness it should be noticed that one might do without large values of  $\hbar$  if the carrier wave with frequency defined by the metabolic energy quantum assignable to the kicking and that the small modulation frequency corresponds to the cyclotron frequency. This would require that Josephson frequency corresponds to the frequency defined by the

metabolic quantum. This is not consistent with the fact that very primitive organisms possess sensory systems.

3. If all primary qualia are assigned to the magnetic body, Josephson radiation must include also gluons and light counterparts of weak bosons are involved besides photons. This is quite a strong additional assumption and it will be found that the identification of sensory qualia in terms of quantum numbers of quark pair restricts them to the cell membrane. The coding of qualia by Josephson frequencies is however possible and makes it possible to regenerate them in nervous system. The successful model explaining the peak frequencies of photoreceptors in terms of ionic cyclotron frequencies supports this view and provides a realization for an old idea about spectroscopy of consciousness which I had already been ready to give up.

#### 4.1.3 Capacitor model of sensory qualia

In capacitor model of sensory receptor the increments of quantum numbers are amplified as particles with given quantum numbers flow between the plates of capacitor like system and the second plate defines the sub-self responsible for the mental image. The generation of complementary qualia assignable to the two plates and bringing in mind complementary colors is predicted. The capacitor is at the verge of di-electric breakdown. The interior and exterior of the receptor cell are the most plausible candidates for the capacitor plates with lipid layers defining the analog of di-electric able to changes its properties. Josephson currents generating Josephson radiation could communicate the sensory percept to the magnetic body but would not generate genuine sensory qualia there (the pitch of sound would be interpreted as a geometric quale). The coding is possible if the basic qualia correspond in one-one manner to ionic Josephson currents. There are sensory receptors which themselves do not fire (this is the case for hair cells for hearing and tactile receptor cells) and in this case the neuron next to the receptor in the sensory pathway would take the role of the quantum critical system.

The notion of sensory capacitor can be generalized. In zero energy ontology the plates could be effectively replaced with positive and negative energy parts of zero energy state or with cyclotron Bose-Einstein condensates corresponding to two different energies. Plates could also correspond to a pair of space-time sheets labeled by different p-adic primes and the generation of quale would correspond in this case to a flow of particles between the space-time sheets or magnetic flux tubes connected by contacts defining Josephson junctions.

The TGD inspired model for photoreceptors [K20] relies crucially on the assumption that sensory neurons at least and probably all cell membranes correspond to nearly vacuum extremals with the value of Weinberg angle equal to  $\sin^2(\theta_W) = .0295$  and weak bosons having Compton length of order cell size and ordinary value of Planck constant. This also explains the large parity breaking effects in living matter. The almost vacuum extremal property conforms with the vision about cell membrane as a quantum critical system ideal for acting as a sensory receptor.

## 4.2 Detailed Model For The Qualia

The proposed vision about qualia requires a lot of new physics provided by TGD. What leads to a highly unique proposal is the intriguing coincidence of fundamental elementary particle time scales with basic time scales of biology and neuro science and the model of DNA as topological quantum computer [K8].

1. Zero energy ontology brings in the size scale of CD assignable to the field body of the elementary particle. Zero energy states with negentropic time-like entanglement between positive and negative energy parts of the state might provide a key piece of the puzzle. The negentropic entanglement (see **Fig.** <http://tgdtheory.fi/appfigures/cat.jpg> or **Fig. ??** in the appendix of this book) between positive energy parts of the states associated with the sub-CD assignable to the cell membrane and sub-CD at the magnetic body is expected to be an important factor.
2. For the standard value of  $\hbar$  the basic prediction would be 1 ms second time scale of  $d$  quark, 6.5 ms time scale of  $u$  quark, and .1 second time scale of electron as basic characterizes of sensory experience if one accept the most recent estimates  $m(u) = 2$  MeV and  $m(d) = 5$

MeV for the quark masses [C3]. These time scales correspond to 10 Hz, 160 Hz, and 1280 Hz frequencies, which all characterize neural activity (for the identification of 160 Hz frequency as cerebellar resonance frequency see [J6] ). Hence quarks could be the most interesting particles as far as qualia are considered and the first working hypothesis would be that the fundamental quantum number increments correspond to those for quark-anti-quark pair. The identification in terms of quantum numbers of single quark is inconsistent with the model of color qualia.

3. The model of DNA as topological quantum computer led to the proposal that DNA nucleotides are connected to the lipids of the cell membrane by magnetic flux tubes having quark and antiquark at its ends such that the  $u$  and  $d$  quarks and their antiquarks code for the four nucleotides. The outer lipid layer was also assumed to be connected by flux tubes to the nucleotide in some other cell or in cell itself.
4. The model for DNA as topological quantum computer did not completely specify whether the flux tubes are ordinary flux tubes or wormhole flux tubes with possibly opposite signs of energy assigned with the members of the flux tube pair. Although it is not necessary, one could assume that the quantum numbers of the two parallel flux tubes cancel each other so that wormhole flux tube would be characterized by quantum numbers of quark pairs at its ends. It is not even necessary to assume that the net quantum numbers of the flux tubes vanish. Color confinement however suggests that the color quantum at the opposite ends of the flux tube are of opposite sign.
  - (a) The absence of a flux tube between lipid layers was interpreted as an isolation from external world during the topological quantum computation. The emergence of the flux tube connection means halting of topological quantum computation. The flux tube connection with the external world corresponds to sensory perception at the level of DNA nucleotide in consistency with the idea that DNA plays the role of the brain of cell [K21]. The total color quantum numbers at the ends of the flux tubes were assumed to sum up to zero. This means that the fusion of the flux tubes ending to the interior and exterior cell membrane to single one creates a flux tube state not localized inside cell and that the interior of cell carries net quantum numbers. The attractive interpretation is that this process represents the generation of quale of single nucleotide.
  - (b) The formation of the flux tube connection between lipid layers would involve the transformation of both quark-antiquark pairs to an intermediate state. There would be no kinematic constraints on the process nor to the mass scales of quarks. A possible mechanism for the separation of the two quark-antiquark pairs associated with the lipids from the system is double reconnection of flux tubes which leads to a situation in which the quark-antiquark pairs associated with the lipid layers are connected by short flux loops and separated to a disjoint state and there is a long wormhole flux tube connecting the nucleotides possibly belonging to different cells.
  - (c) The state of two quark pairs need not have vanishing quantum numbers and one possibility is that the quantum numbers of this state code for qualia. If the total numbers of flux tubes are vanishing also the net quantum numbers of the resulting long flux tube connecting two different cells provide equivalent coding. A stronger condition is that this state has vanishing net quantum numbers and in this case the ends of the long flux tube would carry opposite quantum numbers. The end of flux tube at DNA nucleotide would characterize the quale.
5. Two identification of primary qualia are therefore possible.
  - (a) If the flux tubes have vanishing net quantum numbers, the primary sensory quale can be assigned to single receptor cell and the flow of the quantum numbers corresponds to the extension of the system with vanishing net quantum numbers in two-cell system.
  - (b) If the net quantum numbers of the flux tube need not vanish, the resulting two cell system carries non-vanishing quantum numbers as the pair of quark-antiquark pairs removes net quantum numbers out of the system.

6. If the net quantum numbers for the flux tubes vanish always, the specialization of the sensory receptor membrane to produce a specific quale would correspond to an assignment of specific quantum numbers at the DNA ends of the wormhole flux tubes attached to the lipid layers of the cell membrane. The simplest possibility that one can imagine is that the outer lipid layer is connected to the conjugate DNA nucleotide inside same cell nucleus. This option would however assign vanishing net quantum number increments to the cell as whole and is therefore unacceptable.
7. The formation of a temporary flux tube connection with another cell is necessary during the generation of quale and the question is what kind of cell is in question. The connection of the receptor to cells along the sensory pathway are expected to be present along the entire sensory pathway from DNA nucleotide to a nucleotide in the conjugate strand of second neuron to DNA nucleotide of the third neuron.... If Josephson photons are able to regenerate the quale in second neuron this would make it possible to replicate the quale along entire sensory pathway. The problem is that Josephson radiation has polarization orthogonal to axons and must propagate along the axon whereas the flux tube connection must be orthogonal to axon. Hence the temporary flux tube connection is most naturally between receptor cells and would mean horizontal integration of receptor cells to a larger structure. A holistic process in directions parallel and orthogonal to the sensory pathway would be in question. Of course, the flux tube could be also curved and connect the receptor to the next neuron along the sensory pathway.
8. The specialization of the neuron to sensory receptor would require in the framework of positive energy ontology that -as far as qualia assignable to the electro-weak quantum numbers are considered - all DNA nucleotides are identical by the corresponds of nucleotides with quarks and antiquarks. This cannot be the case. In zero energy ontology and for wormhole flux tubes it is however enough to assume that the net electroweak quantum numbers for the quark antiquark pairs assignable to the DNA wormhole contact are same for all nucleotides. This condition is easy to satisfy. It must be however emphasized that there is no reason to require that all nucleotides involved generate same quale and at the level of neurons sensory maps assigning different qualia to different nucleotides and lipids allowing DNA to sensorily perceive the external world are possible.

The model should be consistent with the assignment of the fundamental bio-rhythms with the CDs of electron and quarks.

1. Quark color should be free in long enough scales and cellular length scales are required at least. The QCD in question should therefore have long enough confinement length scales. The first possibility is provided by almost vacuum extremals with a long confinement scale also at the flux tubes. Large  $\hbar$  for the cell membrane space-time sheet seems to be unavoidable and suggests that color is free in much longer length scale than cell length scale.
2. Since the length of the flux tubes connecting DNA and cell membrane is roughly 1 micrometer and by a factor of order  $10^7$  longer than the  $d$  quark Compton length, it seems that the value of Planck constant must be of this order for the flux tubes. This however scales up the time scale of  $d$  quark CD by a factor of  $10^{14}$  to about  $10^4$  years! The millisecond and 160 ms time scales are much more attractive. This forces to ask what happens to the quark-anti-quark pairs at the ends of the tubes.
3. The only possibility seems to be that the reconnection process involves a phase transition in which the closed flux tube structure containing the two quark pairs assignable to the wormhole contacts at lipid layers is formed and leaks to the page of the Big Book with pages partially labeled by the values of Planck constant. This page would correspond to the standard value of Planck constant so that the corresponding  $d$  quark CDs would have a duration of millisecond. The reconnection leading to the ordinary situation would take place after millisecond time scale. The standard physics interpretation would be as a quantum fluctuation having this duration. This sequence of quark sub-CDs could define what might be called memetic codon representation of the nerve pulse sequence.



4. One can also consider the possibility is that near vacuum extremals give rise to a copy of hadron physics for which the quarks associated with the flux tubes are light. The Gaussian Mersennes corresponding to  $k = 151, 157, 163, 167$  define excellent p-adic time scales for quarks and light variants of weak gauge bosons. Quark mass 5 MeV would with  $k = 120$  would be replaced with  $k = 163$  (167) one would have mass 1.77 eV (.44 eV). Small scaling of both masses gives 2 eV and .5 eV which correspond to basic metabolic quanta in TGD framework. For quark mass of 2 MeV with  $k = 123$   $k = 163$  (167) one would give masses .8 eV (.05 eV). The latter scale correspond to Josephson energy assignable with the membrane potential in the ordinary phase.

In this case a phase transition transforming almost vacuum extremal to ordinary one takes place. What this would mean that the vacuum extremal property would hold true below much shorter p-adic length scale. In zero energy ontology the scaling up of quark masses is in principle possible. This option looks however too artificial.

### 4.3 Overall View About Qualia

This picture leads to the following overall view about qualia. There are two options depending on whether single quark-antiquark pair or two of them labels the qualia. In the following only the simpler option with single quark-antiquark pair is discussed.

1. All possible pairings of spin and electroweak isospin (or em charge) define 16 basic combinations if one assumes color singletness. If arbitrary color is allowed, there is a nine-fold increase of quantum numbers decomposable to color singlet and octet qualia and further into  $3 \times 15$  qualia with vanishing increments of color quantum numbers and  $6 \times 16$  qualia with non-vanishing increments of color quantum numbers. The qualia with vanishing increments for electroweak quantum numbers could correspond to visual colors. If electroweak quantum numbers of the quark-anti-quark pair vanish, one has  $3 \times 7$  *resp.*  $6 \times 8$  combinations of colorless *resp.* colored qualia.
2. There is a huge number of various combinations of these fundamental qualia if one assumes that each nucleotide defines its own quale and fundamental qualia would be analogous to constant functions and more general qualia to general functions having values in the space with  $9 \times 16 - 1$  points. Only a very small fraction of all possible qualia could be realized in living matter unless the neurons in brain provide representations of body parts or of external world in terms of qualia assignable to lipid-nucleotide pairs. The passive DNA strand would be ideal in this respect.
3. The basic classification of qualia is as color qualia, electro-weak quale, and spin quale and products of these qualia. Also combinations of color qualia and and electroweak and spin quale are possible and could define exotic sensory qualia perhaps not yet realized in the evolution. Synesthesia is usually explained in terms of sensory leakage between sensory pathways and this explanation makes sense also in TGD framework if there exists a feedback from the brain to the sensory organ. Synesthesia cannot however correspond to the product qualia: for “quantum synesthesia” cross association works in both directions and this distinguishes it from the ordinary synesthesia.
4. The idea about brain and genome as holograms encourages to ask whether neurons or equivalently DNA could correspond to sensory maps with individual lipids representing qualia combinations assignable to the points of the perceptive field. In this framework quantum synesthesia would correspond to the binding of qualia of single nucleotide (or lipid) of neuron cell membrane as a sensory representation of the external world. DNA is indeed a holographic representation of the body (gene expression of course restricts the representation to a part of organism). Perhaps it is this kind of representation also at the level of sensory experience so that all neurons could be little sensory copies of body parts as holographic quantum homunculi. In particular, in the associative areas of the cortex neurons would be quantum synesthetes experiencing the world in terms of composite qualia.
5. The number of flux tube connections generated by sensory input would code for the intensity of the quale. Josephson radiation would do the same at the level of communications to the

magnetic body. Also the temporal pattern of the sequence of quale mental images matters. In the case of hearing this would code for the rhythmic aspects and pitch of the sound.

#### 4.4 About Detailed Identification Of The Qualia

One can make also guesses about detailed correspondence between qualia and quantum number increments.

1. Visual colors would correspond to the increments of only color quantum numbers. Each biologically important ion would correspond to its own color increment in one-one correspondence with the three pairs of color-charged gluons and these would correspond to blue-yellow, red-green, and black white [K20]. Black-white vision would mean a restriction to the  $SU(2)$  subgroup of color group. The model for the cell membrane as a nearly vacuum extremal assigns the peak frequencies corresponding to fundamental colors with biologically important ions. Josephson radiation could induce artificially the same color qualia in other neurons and this might provide a manner to communicate the qualia to the brain where they could be re-experienced at neuronal level. Some organisms are able to perceive also the polarization of light. This requires receptors sensitive to polarization. The spin of quark pair would naturally code for polarization quale.
2. Also tastes and odours define qualia with “colors”. Certainly the increments of electroweak numbers are involved but since these qualia do not have any directional flavor, spin is probably not involved. This would give  $c 3 \times 4$  basic combinations are possible and can certainly explain the 5 or 6 basic tastes (counted as the number of different receptors). Whether there is a finite number of odours or not has been a subject of a continual debate and it might be that odours already correspond to a distribution of primary qualia for the receptor cell. That odours are coded by nerve pulse patterns for a group of neurons [J8] would conform with this picture.
3. Hearing seems to represent a rather colorless quale so that electroweak isospin suggests again itself. If we had a need to hear transversely polarized sound also spin would be involved. Cilia are involved also with hair cells acting as sensory receptors in the auditory system and vestibular system. In the case of hearing the receptor itself does not fire but induces a firing of the higher level neuron. The temporal pattern of qualia mental images could define the pitch of the sound whereas the intensity would correspond to the number of flux tube connections generated.

The modulation of Josephson frequencies -rather than Josephson frequencies as such- would code for the pitch and the total intensity of the Josephson radiation for the intensity of the sound and in fact any quale. Pitch represents non-local information and the qualia sub-selves should be negentropically entangled in time direction. If not, the experience corresponds to a sequence of sound pulses with no well-defined pitch and responsible for the rhythmic aspects of music. Right brain sings-left brain talks metaphor would suggest that right and left brain have different kind of specializations already at the level of sensory receptors.

4. Somato-sensory system gives rise to tactile qualia like pain, touch, temperature, proprioception (body position). There are several kinds of receptors: nociceptors, mechanoreceptors, thermoreceptors, etc... Many of these qualia have also emotional coloring and it might be that the character of entanglement involved (negentropic/entropic defines the emotional color of the quale. If this is the case, one might consider a pure quale of touch as something analogous to hearing quale. One can argue that directionality is basic aspect of some of these qualia -say sense of touch- so that spin could be involved besides electroweak quantum numbers. The distribution of these qualia for the receptor neuron might distinguish between different tactile qualia.

#### 4.5 Recent TGD based view about qualia

The TGD inspired theory of qualia [K11] has evolved gradually and the recent view differs from the above described picture in some aspects.

1. The original vision was that qualia and other aspects of consciousness experience are determined by the change of quantum state in the reduction: the increments of quantum numbers would determine qualia. I had not yet realized that repeated state function reduction (Zeno effect) realized in ZEO is central for consciousness. The objection was that qualia change randomly from reduction to reduction.
2. Later I ended up with the vision that the rates for the changes of quantum numbers would determine qualia: this idea was realized in terms of sensory capacitor model in which qualia would correspond to kind of generalized di-electric breakdown feeding to subsystem responsible for quale quantum numbers characterizing the quale. The Occamistic objection is that the model brings in an additional element not present in quantum measurement theory.
3. The view that emerged while writing the critics of IIT of Tononi is that qualia correspond to the quantum numbers measured in the state function reduction. That in ZEO the qualia remain the same for the entire sequence of repeated state function reductions is not a problem since qualia are associated with sub-self (sub-CD), which can have lifetime of say about .1 seconds! Only the generalization of standard quantum measurement theory is needed to reduce the qualia to fundamental physics. This for instance supports the conjecture that visual colors correspond to QCD color quantum numbers. This makes sense in TGD framework predicting a scaled variants of QCD type physics even in cellular length scales.

This view implies that the model of sensory receptor based on the generalization of di-electric breakdown [K15] is wrong as such since the rate for the transfer of the quantum numbers would not define the quale. A possible modification of the model simple: the analog of di-electric breakdown generates Bose-Einstein condensate and the the quantum numbers for the BE condensate give rise to qualia assignable to sub-self.

## 5 Could Cell Membrane Correspond To Almost Vacuum Extremal?

The question whether cell membrane or even cell could correspond almost vacuum extremal of Kähler action (in some cases) was the question which led to the realization that the frequencies of peak sensitivity for photoreceptors correspond to the Josephson frequencies of biologically important ions if one accepts that the value of the Weinberg angle equals to  $\sin^2(\theta_W) = .0295$  instead of the value .23 in the normal phase, in which the classical electromagnetic field is proportional to the induced Kähler form of  $CP_2$  in a good approximation. Another implication made possible by the large value of Planck constant is the identification of Josephson photons as the counterparts of bio-photons one one hand and those of EEG photons on the other hand. These observation in turn led to a detailed model of sensory qualia and of sensory receptor. Therefore the core of this argument deserves to be represented also here although it has been discussed in [K20].

### 5.1 Cell Membrane As Almost Vacuum Extremal

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

1. Classical electric fields are in a fundamental role in biochemistry and living biosystems are typically electrets containing regions of spontaneous electric polarization. Fröhlich [I4] proposed that oriented electric dipoles form macroscopic quantum systems with polarization density serving as a macroscopic order parameter. Several theories of consciousness share this hypothesis. Experimentally this hypothesis has not been verified.
2. TGD suggests much more profound role for the unique di-electric properties of the biosystems. The presence of strong electric dipole fields is a necessary prerequisite for cognition and life and could even force the emergence of life. Strong electric fields imply also the presence of the charged wormhole BE condensates: the surface density of the charged wormholes on the boundary is essentially equal to the normal component of the electric field so that

wormholes are in some sense “square root” of the dipole condensate of Fröhlich! Wormholes make also possible pure vacuum polarization type dipole fields: in this case the magnitudes of the em field at the two space-time sheets involved are same whereas the directions of the fields are opposite. The splitting of wormhole contacts creates fermion pairs which might be interpreted as cognitive fermion pairs. Also microtubules carry strong longitudinal electric fields. This formulation emerged much before the identification of ordinary gauge bosons and their superpartners as wormhole contacts.

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

1. The configuration could be a small deformation of vacuum extremal so that the system would be highly critical as one indeed expects on basis of the general vision about living matter as a quantum critical system. For vacuum extremals classical em and  $Z^0$  fields would be proportional to each other. The second half of Maxwell’s equations is not in general satisfied in TGD Universe and one cannot exclude the presence of vacuum charge densities in which case elementary particles as the sources of the field would not be necessarily. If one assumes that this is the case approximately, the presence of  $Z^0$  charges creating the classical  $Z^0$  fields is implied. Neutrinos are the most candidates for the carrier of  $Z^0$  charge. Also nuclei could feed their weak gauge fluxes to almost non-vacuum extremals but not atomic electrons since this would lead to dramatic deviations from atomic physics. This would mean that weak bosons would be light in this phase and also Weinberg angle could have a non-standard value.
2. There are also space-time surfaces for  $CP_2$  projection belongs to homologically non-trivial geodesic sphere. In this case classical  $Z^0$  field can vanish [L1], [L1] and the vision has been that it is sensible to speak about two basic configurations.
  - (a) Almost vacuum extremals (homologically trivial geodesic sphere).
  - (b) Small deformations of non-vacuum extremals for which the gauge field has pure gauge  $Z^0$  component (homologically non-trivial geodesic sphere).

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

3. To see whether the latter configurations are really possible one must understand how the gauge fields are affected in the color rotation.
  - (a) The action of color rotations in the holonomy algebra of  $CP_2$  is non-trivial and corresponds to the action in  $U(2)$  sub-group of  $SU(3)$  mapped to  $SU(2)_L \times U(1)$ . Since the induced color gauge field is proportional to Kähler form, the holonomy is necessary Abelian so that also the representation of color rotations as a sub-group of electro-weak group must correspond to a local  $U(1)$  sub-group local with respect to  $CP_2$  point.
  - (b) Kähler form remains certainly invariant under color group and the right handed part of  $Z^0$  field reducing to  $U(1)_R$  sub-algebra should experience a mere Abelian gauge transformation. Also the left handed part of weak fields should experience a local  $U(1)_L$  gauge rotation acting on the neutral left handed part of  $Z^0$  in the same manner as it acts on the right handed part. This is true if the  $U(1)_L$  sub-group does not depend on point of  $CP_2$  and corresponds to  $Z^0$  charge. If only  $Z^0$  part of the induced gauge field is non-vanishing as it can be for vacuum extremals then color rotations cannot change the situation. If  $Z^0$  part vanishes and non-vacuum extremal is in question, then

color rotation rotation of  $W$  components mixing them but acts as a pure  $U(1)$  gauge transformation on the left handed component.

- (c) It might not be without importance that for any partonic 2-surface induced electro-weak gauge fields have always  $U(1)$  holonomy, which could allow to define what neutral part of induced electroweak gauge field means locally. This does not however hold true for the 4-D tangent space distribution. In any case, the cautious conclusion is that there are two phases corresponding to nearly vacuum extremals and small deformations of extremals corresponding to homologically non-trivial geodesic spheres for which the neutral part of the classical electro-weak gauge field reduces to photon field.
4. The unavoidable presence of long range  $Z^0$  fields would explain large parity breaking in living matter, and the fact that neutrino Compton length is of the order of cell size would suggest the possibility that within neutrino Compton electro-weak gauge fields or even longer scales could behave like massless fields. The explanation would be in terms of the different ground state characterized also by a different value of Weinberg angle. For instance, of the p-adic temperature of weak bosons corresponds to  $T_p = 1/2$ , the mass scale would be multiplied by a factor  $\sqrt{M_{89}}$  and Compton lengths of weak bosons would be around  $10^{-4}$  meters corresponding to the size scale of a large neuron. If the value of Planck constant is also large then the Compton length increases to astrophysical scale.
  5. From the equations for classical induced gauge fields in terms of Kähler form and classical  $Z^0$  field [L1] , [L1]

$$\gamma = 3J - \frac{p}{2}Z^0 \quad , \quad Q_Z = I_L^3 - pQ_{em} \quad , \quad p = \sin^2(\theta_W) \quad (5.1)$$

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

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

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

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

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

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

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

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

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

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

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

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

Here  $n$  refers to the cyclotron harmonic.

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

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

If cell membrane corresponds to an almost vacuum extremal, the membrane potential potential is replaced with an effective resting potential containing also the  $Z^0$  contribution proportional to the ordinary resting potential. The surprising outcome is that one could understand the preferred frequencies for photo-receptors [J3] as Josephson frequencies for biologically important ions. Furthermore, most Josephson energies are in visible and UV range and the interpretation in terms of bio-photons is suggestive. If the value of Planck constant is large enough Josephson frequencies are in EEG frequency range so that bio-photons and EEG photons could be both related to Josephson photons with large  $\hbar$ .

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

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

1. One must assume that the interior of the cell corresponds to many fermion state -either a state filled with neutrinos up to Fermi energy or Bose-Einstein condensate of neutrino Cooper pairs creating a harmonic oscillator potential. The generalization of nuclear harmonic oscillator model so that it applies to multi-neutrino state looks natural.
2. For exact vacuum extremals elementary fermions couple only via left-handed isospin to the classical  $Z^0$  field whereas the coupling to classical em field vanishes. Both  $K_+$ ,  $Na_+$ , and  $Cl_-$   $A - Z = Z + 1$  so that by p-n pairing inside nucleus they have the weak isospin of neutron (opposite to that of neutrino) whereas  $Ca_{++}$  nucleus has a vanishing weak isospin. This might relate to the very special role of  $Ca_{++}$  ions in biology. For instance,  $Ca_{++}$  defines an action potential lasting a time of order.1 seconds whereas  $Na_+$  defines a pulse lasting for about 1 millisecond [J1]. These time scales might relate to the time scales of CDs associated with quarks and electron.
3. The basic question is whether only nuclei couple to the classical  $Z^0$  field or whether also electrons do so. If not, then nuclei have a large effective vector coupling to em field coming from  $Z^0$  coupling proportional to the nuclear charge increasing the value of effective membrane potential by a factor of order 100. If both electrons and nuclei couple to the classical  $Z^0$  field, one ends up with difficulties with atomic physics. If only quarks couple to the  $Z^0$  field and one has  $Z^0 = -2\gamma/p$  for vacuum extremals, and one uses average vectorial coupling  $\langle I_L^3 \rangle = \pm 1/4$  with + for proton and - for neutron, the resulting vector coupling is following

$$\begin{aligned} \left(\frac{Z-N}{4} - pZ\right)Z^0 + q_{em}\gamma &= Q_{eff}\gamma , \\ Q_{eff} &= -\frac{Z-N}{2p} + 2Z + q_{em} . \end{aligned} \quad (5.2)$$

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

## 5.2 Are Photoreceptors Nearly Vacuum Extremals?

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

Photoreceptors can be classified to three kinds of cones responsible for color vision and rods responsible for black-white vision. The peak sensitivities of cones correspond to wavelengths (405, 535, 565) nm and energies (3.06, 2.32, 2.19) eV. The maximum absorption occurs in the wavelength range 420-440 nm, 534-545 nm, 564-580 nm for cones responsible for color vision and 498 nm for rods responsible black-white vision [J2, J3]. The corresponding photon energies are (2.95, 2.32, 2.20) eV for color vision and to 2.49 eV for black-white vision. For frequency distribution the maxima are shifted from these since the maximum condition becomes  $dI/d\lambda + 2I/\lambda = 0$ , which means a shift to a larger value of  $\lambda$ , which is largest for smallest  $\lambda$ . Hence the energies for maximum absorbance are actually lower and the downwards shift is largest for the highest energy.

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

Consider first the construction of the model.

1.  $Na^+$  and  $Ca^{++}$  currents are known to present during the activation of the photoreceptors.  $Na^+$  current defines the so called dark current [J3] reducing the membrane resting potential below its normal value and might relate to the sensation of darkness as eyes are closed. Hodgkin-Huxley model predicts that also  $K^+$  current is present. Therefore the Josephson energies of these three ion currents are the most plausible correlates for the three colors.
2. One ends up with the model in the following manner. For  $Ca^{++}$  the Josephson frequency does not depend on  $p$  and requiring that this energy corresponds to the energy 2.32 eV of maximal sensitivity for cones sensitive to green light fixes the value of the membrane potential during hyper-polarization to  $V = .055$  V, which is quite reasonable value. The value of the Weinberg angle parameter can be fixed from the condition that other peak energies are reproduced optimally. The result of  $p = .0295$ .

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

1. The resting potential for photoreceptors is  $V = -40$  mV [J4]. In this case all Josephson energies are below the range of visible frequencies for  $p = .23$ . Also for maximal hyper-polarization  $Na^+$  Josephson energy is below the visible range for this value of Weinberg angle.
2. For  $V = -40$  mV and  $p = .0295$  required by the model the energies of  $Cl^-$  and  $K^+$  Josephson photons correspond to red light. 2 eV for  $Cl^-$  corresponds to a basic metabolic quantum. For  $Na^+$  and  $Ca^{++}$  the wave length is below the visible range.  $Na^+$  Josephson energy is below visible range. This conforms with the interpretation of  $Na^+$  current as a counterpart for the sensation of darkness.
3. For  $V = -55$  mV - the threshold for the nerve pulse generation- and for  $p = .0295$  the Josephson energies of  $Na^+$ ,  $Ca^{++}$ , and  $K^+$  correspond to the peak energies for cones sensitive to red, green, and blue respectively. Also  $Cl^-$  is in the blue region.  $Ca^{++}$  Josephson energy can be identified as the peak energy for rods. The increase of the hyper-polarization to  $V = -59$  mV reproduces the energy of the maximal wave length response exactly. A possible interpretation is that around the criticality for the generation of the action potential ( $V \simeq -55$  mV) the qualia would be generated most intensely since the Josephson currents would be strongest and induce Josephson radiation inducing the quale in other neurons of the visual pathway at the verge for the generation of action potential. This supports the earlier idea that visual pathways defines a neural window. Josephson radiation could be interpreted as giving rise to bio-photons (energy scale is correct) and to EEG photons (for large enough values of  $\hbar$  the frequency scales is that of EEG).
4. In a very bright illumination the hyper-polarization is  $V = -65$  mV [J4], which the normal value of resting potential. For this voltage Josephson energies are predicted to be in UV region except in case of  $Ca^{++}$ . This would suggest that only the quale "white" is generated at the level of sensory receptor: very intense light is indeed experienced as white.



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

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

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

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

1. The maximum value of the action potential is +40 mV so that Josephson frequencies are same as for the resting state of photoreceptor. Note that the time scale for nerve pulse is so slow as compared to the frequency of visible photons that one can consider that the neuronal membrane is in a state analogous to that of a photoreceptor.
2. For neurons the value of the resting potential is -70 mV.  $Na^+$  and  $Ca^{++}$  Josephson energies 2.80 eV and 2.94 eV are in the visible range in this case and correspond to blue light. This does not mean that  $Ca^{++}$  Josephson currents are present and generate sensation of blue at neuronal level: the quale possibly generated should depend on sensory pathway. During the hyper-polarization period with -75 mV the situation is not considerably different.
3. The value of the resting potential is -95 mV for skeletal muscle cells. In this case  $Ca^{++}$  Josephson frequency corresponds to 4 eV metabolic energy quantum as **Table 1** shows.
4. For smooth muscle cells the value of resting potential is -50 mV. In this case  $Na^+$  Josephson frequency corresponds to 2 eV metabolic energy quantum.
5. For astroglia the value of the resting potential is -80/-90 mV for astroglia. For -80 mV the resting potential for  $Cl^-$  corresponds to 4 eV metabolic energy quantum. This suggests that glial cells could also provide metabolic energy as Josephson radiation to neurons.
6. For all other neurons except photo-receptors and red blood cells Josephson photons are in visible and UV range and the natural interpretation would be as bio-photons. The bio-photons detected outside body could represent sensory leakage. An interesting question is whether the IR Josephson frequencies could make possible some kind of IR vision.

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

A possible cure could be that the voltage is not same for different ions. This is possible since at microscopic level the Josephson junctions correspond to transmembrane proteins acting as channels and pumps. The membrane potential through receptor protein is different for color receptors. For this option one would have the correspondences

$Na^+ \leftrightarrow 2.19$  eV (R) and  $eV = 86.8$  eV,

$Cl^- \leftrightarrow 2.32$  eV (G) and  $eV = 65.8$  eV,

$K^+ \leftrightarrow 2.49$  eV (W) and  $eV = 60.2$  eV,

$Ca^{++} \leftrightarrow 3.06$  eV (B) and  $eV = 67.3$  meV.

For  $Na^+$  the value of the membrane potential is suspiciously large.

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

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

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

which is not far from unity so that the cyclotron frequency would be near to that for proton for all ions. Also neutral atoms would experience classical and magnetic  $Z^0$  fields. Cyclotron frequency would be almost particle independent so that cyclotron contribution gives an almost constant shift to the generalized Josephson energy. When the difference of cyclotron energies vanishes, the model reduces to that discussed above.

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

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

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

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

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

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

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

One can find a biographical sketch [I2] (<http://faculty.washington.edu/ghp/cv/>) giving a list of publications containing items related to the notions of exclusion zone and fourth phase of water discussed in the talk.

## 6.1 Pollack's Findings

I list below some basic experimental findings about fourth gel like phase of water made in the laboratory led by Gerald Pollack [I3].

1. In water bounded by a gel a layer of thickness up to 100-200 microns is formed. All impurities in this layer are taken outside the layer. This motivates the term "exclusion zone". The layer consists of layers of molecular thickness and in these layers the stoichiometry is  $H_{1.5}O$ . The layer is negatively charged. The outside region carries compensating positive charge. This kind of blobs are formed in living matter. Also in the splitting of water producing Brown's gas negatively charged regions are reported to emerge [H8, H1].
2. The process requires energy and irradiation by visible light or thermal radiation generates the layer. Even the radiation on skin can induce the phase transition. For instance, the blood flow in narrow surface veins requires metabolic energy and irradiation forces the blood to flow.
3. The layer can serve as a battery: Pollack talks about a form of free energy deriving basically from solar radiation. The particles in the layer are taken to the outside region, and this makes possible disinfection and separation of salt from sea water. One can even understand how clouds are formed and mysteries related to the surface tension of water as being due the presence of the layer formed by  $H_{1.5}O$ .
4. In the splitting of water producing Brown's gas [H8, H1] having a natural identification as Pollack's fourth phase of water the needed energy can come from several alternative sources: cavitation, electric field, etc...

## 6.2 Dark Nuclei And Pollack's Findings

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

### 6.2.1 Model for the formation of exclusion zones

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

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

2. An interesting question is whether the magnetic body is created by the electronic currents or whether it consists of flux tubes carrying monopole flux: in the latter case no currents would be needed. This is obviously purely TGD based possibility and due to the topology of  $CP_2$ .
3. This means that in the model inspired by the lectures of Moray B. King discussed above, one just replaces the sequences of partially dark water molecules with sequences of dark protons at the magnetic body of the  $H1.5O$  blob. The model for the proto-variants of photosynthesis and metabolism remain as such. Also now genetic code would be realized [K12, L2].
4. The transfer of impurities from the exclusion zone could be interpreted as a transfer of them to the magnetic flux tubes outside the exclusion zone as dark matter.

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

The liberation of energy would involve increase of the p-adic prime characterizing the flux tubes and reduction of Planck constant so that the thickness of the flux tubes remains the same but the intensity of the magnetic field is reduced. The cyclotron energy of dark protons is liberated in coherent fashion and in good approximation the frequencies of the radiation corresponds to multiples of cyclotron frequency: this prediction is consistent with that in the original model for the findings of Blackman and others [J5].

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

### 6.2.2 Minimal metabolic energy consumption and the value of membrane potential

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

1. The Josephson radiation generated by cell membrane has photon energies coming as multiples of  $ZeV$ , where  $V$  is membrane potential about .06 V and  $Z = 2$  is the charge of electron Cooper pair. This gives  $E = .12$  eV.
2. There is a danger that thermal radiation masks Josephson radiation. The energy for photons at the maximum of the energy density of blackbody radiation as function of frequency is given as the maximum of function  $x^3/(e^x - 1)$ ,  $x = E/T$  given by  $e^{-x} + x/3 - 1 = 0$ . The maximum is given approximately by  $x = 3$  and thus  $E_{max} \simeq 3T$  (in units  $c = 1, k_B = 1$ ). At physiological temperature  $T = 310$  K (37 C) this gives .1 eV, which is slightly below Josephson energy: living matter seems to have minimized the value of Josephson energy - presumably to minimize metabolic costs. Note however that for the thermal energy density as function of *wavelength* the maximum is at  $E \simeq 5T$  corresponding to 1.55 eV which is larger than Josephson energy. The situation is clearly critical.
3. One can ask whether also a local reduction of temperature around cell membrane in the fourth phase of water is needed.

“Electric expansion” of water giving rise to charge separation and presumably creating fourth phase of water is reported to occur [H8, H1].

- (b) Could the electric expansion/phase transition to dark phase be adiabatic involving therefore no heat transfer between the expanding water and environment? If so, it would transform some thermal energy of expanding water to work and reduce its temperature. The formula for the adiabatic expansion of ideal gas with  $f$  degrees of freedom for particle ( $f = 3$  if there are no other than translational degrees of freedom) is

$(T/T_0) = (V/V_0)^{-\gamma}$ ,  $\gamma = (f + 2)/f$ . This gives some idea about how large reduction of temperature might be involved. If p-adic scaling for water volume by a power of two takes place, the reduction of temperature can be quite large and it does not look realistic.

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

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

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

#### 6.3.1 Metabolism and fourth phase of water

1. Cell interiors, in particular the interior of the inner mitochondrial membrane are negatively charged as the regions formed in Pollack's experiments. Furthermore, the citric acid cycle, ([http://www.en.wikipedia.org/wiki/Citric\\_acid\\_cycle](http://www.en.wikipedia.org/wiki/Citric_acid_cycle)), which forms the basic element of both photosynthesis (<http://www.en.wikipedia.org/wiki/Photo-synthesis>) and cellular respiration ([http://www.en.wikipedia.org/wiki/Cellular\\_respiration](http://www.en.wikipedia.org/wiki/Cellular_respiration)), involves electron transport chain ([http://www.en.wikipedia.org/wiki/Electron\\_transport\\_chain](http://www.en.wikipedia.org/wiki/Electron_transport_chain)) in which electron loses gradually its energy via production of NADP and proton at given step. Protons are pumped to the other side of the membrane and generates proton gradient serving as metabolic energy storage just like battery. The interpretation for the electron transport chain in terms of Pollack's experiment would be in terms of generation of dark protons at the other side of the membrane.
2. When ATP is generated from ADP three protons per ATP flow back along the channel formed by the ATP synthase molecule ([http://www.en.wikipedia.org/wiki/ATP\\_synthase](http://www.en.wikipedia.org/wiki/ATP_synthase)) (perhaps Josephson junction) and rotate the shaft of a "motor" acting as a catalyst generating three ATP molecules per turn by phosphorylating ADP. The TGD based interpretation is that dark protons are transformed back to ordinary ones and possible negentropic entanglement is lost.
3. ATP is generated also in glycolysis (<http://www.en.wikipedia.org/wiki/Glycolysis>), which is ten-step process occurring in cytosol so that membrane like structure need not be involved. Glycolysis involves also generation of two NADH molecules and protons. An open question (to me) is whether the protons are transferred through an endoplasmic reticulum or from a region of ordered water (fourth phase of water) to its exterior so that it would contribute to potential gradient and could go to magnetic flux tubes as dark proton. This would be natural since glycolysis is realized for nearly all organisms and electron transport chain is preceded by glycolysis and uses as input the output of glycolysis (two pyruvate molecules (<http://www.en.wikipedia.org/wiki/Pyruvate>)).
4. Biopolymers - including DNA and ATP - are typically negatively charged. They could thus be surrounded by fourth phase of water and neutralizing protons would reside at the magnetic bodies. This kind of picture would conform with the idea that the fourth phase (as also magnetic body) is fractal like. In phosphorylation the metabolic energy stored to a potential difference is transferred to shorter length scales (from cell membrane scale to molecular scale).

In glycolysis (<http://www.en.wikipedia.org/wiki/Glycolysis>) the net reaction  $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2(g) + 6H_2O(l) + heat$  takes place. The Gibbs free energy change is  $\Delta G = -2880$  kJ per mole of  $C_6H_{12}O_6$  and is negative so that the process takes place spontaneously. Single glucose

molecule is theoretized to produce  $N = 38$  ATP molecules in optimal situation but there are various energy losses involved and the actual value is estimated to be 29-30. From  $Joule = 6.84 \times 10^{18}$  eV and  $mol = 6.02 \times 10^{23}$  and for  $N = 38$  one would obtain the energy yield.86 eV per single ATP. The nominal value that I have used.5 eV. This is roughly 5 to 8 times higher than  $E = ZeV, Z = 2$ , which varies in the range.1-16 eV so that the metabolic energy gain cannot be solely due to the electrostatic energy which would actually give only a small contribution.

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

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

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

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

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

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

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

#### 1. Simplest Josephson junction model for cell membrane

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

1. Josephson junctions correspond microscopically to transmembrane proteins defining channels and pumps. In rougher description entire cell membrane is described as Josephson junction.
2. The magnetic field strength at flux tube can differ at the opposite side of the membrane and even the values of  $h_{eff}$  could in principle be different. The earlier modelling attempts suggest that  $h_{eff}/h = n = 2^k A$ , where  $A$  is the atomic weight of ion, is a starting assumption deserving testing. This would mean that each ion resides at its own flux tubes.

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

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

1. The simplest model for Josephson junction defined by the transmembrane protein is as a two state system  $(\Psi_1, \Psi_2)$  obeying Schrödinger equation.

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

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

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

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

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

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

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

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

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

#### 2. The counterpart of chemical potential in TGD description

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

1. The most obvious possibility is that also the chemical potential actually correspond to an interaction energy - most naturally the cyclotron energy  $E_c = \hbar_{eff} ZeB_{end}/m$  of ion - in this case proton - at the magnetic flux tube. Cyclotron energy is proportional to  $h_{eff}$  and can be rather large as assumed in the model for the effects of ELF em fields on brain.
2. This model would predict the dependence of the effective chemical potential on the mass and charge of ion for a fixed value of on  $h_{eff}$  and  $B_{end}$ . The scales of ionic chemical potential and ion concentrations would also depend on value of  $h_{eff}$ .
3. The model would provide a different interpretation for the energy scale of bio-photons, which is in visible range rather than infrared as suggested by the value of membrane potential.

The earlier proposal [K11] was that cell membrane can be in near vacuum extremal configuration in which classical  $Z^0$  field contributes to the membrane potential and gives a large contribution for ions. The problematic aspect of the model was the necessity to assume Weinberg angle in this phase to have much smaller value than usually. This difficulty could be perhaps avoided by noticing that the membrane potentials can differ for color receptors so that the earlier assignment of specific ions to color receptors could make sense for ordinary value of Weinberg angle. Second problem is that for proton the  $Z^0$  contribution is negligible in good approximation so that this model does not explain the high value of the metabolic energy currency.

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

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

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

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

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

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

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

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

### 6.3.3 Why would charge separation generate large $h_{eff}$ ?

The basic question is whether and how the separation of electron and proton charges generates large  $h_{eff}$ ? A possible mechanism emerged from a model [K32] explaining anomalously large gravimagnetic effect claimed by Tajmar et al [E2, E3] to explain the well-established anomaly related to the mass of Cooper pairs in rotating super-conduction. The mass is too large by fraction of order  $10^{-4}$  and the proposal is that gravimagnetism changes slightly the effective Thomson magnetic field associated with the rotating super-conductor leading to wrong value of Cooper pairs mass when only ordinary Thomson field is assumed to be present. The needed gravimagnetic field is however gigantic: 28 orders larger than that predicted by GRT. Gravimagnetic field is proportional  $h_{eff}^2$  in TGD and if one uses  $h_{gr}$  for electron-Earth system one obtains correct order of magnitude.

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



1. By Equivalence Principle  $h_{gr}$  has the general form  $h_{gr} = GMm/v_0$ , where  $M$  and  $m$  are the interacting masses and  $v_0$  is a parameter with dimensions of velocity. For three inner planets one has  $v_0/c \simeq 2^{-11}$ .
2. The notion of  $h_{gr}$  generalizes to that for other interactions. For instance, in electromagnetic case the formation of strong em fields implying charge separation leads to systems in which  $h_{em} = Z_1 Z_2 e^2/v_0$  is large. Pollack's exclusion zone and its complement define this kind of systems and is identified as prebiotic life form.
3. Since the natural expansion parameter of perturbative expansion is the  $g^2/4\pi\hbar$ , one can say that transition to dark matter phase make the situation perturbative. Mother Nature is theoretician friendly.

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

1. EZ carries very large negative charge with positive charge outside the exclusion zone.
2. TGD interpretation is in terms of  $H_{1.5}O$  phase of water formed when every 4: th proton is transferred to magnetic body as dark particle with large value of  $h_{eff}$ . The proposal is that primitive life form is in question.
3. The pair formed by EZ and its complement could have large value of  $h_{eff} = h_{em} = Z^2 e^2/v_0$ .
4. The velocity parameter  $v_0$  should correspond to some natural rotation velocity. What comes in mind is that complement refers to Earth and  $v_0$  is the rotation velocity at the surface of Earth. The prediction for  $h_{eff}$  would be of order  $h_{em}/h = 4\pi\alpha Z^2 \times .645 \times 10^6 \simeq 5.9 \times 10^4 Z^2$ .
5. Cell membrane involves also large charge separation due to very strong electric field over the cell membrane. Also now dark phases with large  $h_{em}$  or  $h_{gr}$  could be formed.

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

1. I have speculated earlier [K14] that the rotating shaft of a molecular motor associated with ATP synthase plays a key role in generating dark matter phase. What comes in mind is that charge separation takes place associating exclusion zone with the shaft and the rotational velocity  $v_0$  of the shaft appears in the formula for  $h_{em}$ . Of course, some numerical constant not far from unity could be present. The electric field over the mitochondrial membrane generates charge separation. One can imagine several identifications for the product of charges. The charge  $Z$  associated with the complement would be naturally associated with single dark flux tube containing dark nucleon consisting of dark protons. For instance, the charge associated with the exclusion zone could be the charge of the electronic Cooper pair giving  $h_{em} = 2e \times Z/v_0$ .
2. The value of  $v_0/c$  is expected to be of order  $10^{-14}$  from the angular rotation rate of ADP synthase about few hundred revolutions per second. The order of magnitude for  $h_{em}$  could be same as for  $h_{gr}$  associated with Earth-particle system.

$h_{eff}(ATP\text{synthase}) = h_{gr}(2e, Earth)$  would make possible reconnection of electromagnetic flux tubes with gravimagnetic flux tubes [K19].

#### 6.3.4 Which came first: metabolism or cell membrane?

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

1. The above view suggests that both approaches are correct to some degree in TGD Universe. Both metabolism and genetic code realized in terms of dark proton sequences would have emerged simultaneously and bio-chemistry self-organized around them. Dark proton sequences defining analogs of amino-acid sequences could have defined analogs of protein

catalysts and played a key role in the evolution of the metabolic pathways from the primitive pathways involving only the phase transition between ordinary water and fourth phase of water.

2. There is very interesting article [?]eorting that complex metabolic pathways are generated spontaneously in laboratory environments mimicking hot thermal vents. Glycolysis and pentose phosphate pathway were detected. The proposal is that these pathways are catalyzed by metals rather than protein catalysts.
3. In standard biology these findings would mean that these metabolic pathways emerged before basic biopolymers and that genetic code is not needed to code for the metabolic pathways during this period. In TGD framework dark genetic code [K12, L2] would be there, and could code for the dark pathways. Dark proton strings in one-one correspondence with the amino-acid sequences could be responsible for catalysts appearing in the pathways. Only later these catalysts would have transformed to their chemical counterparts and might be accompanied by their dark templates. One cannot even exclude the possibility that the chemical realization of the DNA-amino-acid correspondence involves its dark analog in an essential manner.

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

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

### 6.4.1 Clarendon pile: 175 years old battery still working

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

The function principle of the clock is simple. The gravitational field of earth is also present. When the sphere touches the negative electrode, it receives a bunch of electrons and gives the bunch away as it touches positive electrode so that a current consisting of these bunches is running between electrons. The average current during the oscillation period of 2 seconds is nanoampere so that nanocoulomb of charge is transferred during each period (Coulomb corresponds to a  $6.242 \times 10^{18}$  elementary charges (electrons)).

The dry pile was discovered by priest and physicist Giuseppe Zamboni at 1812 (see <http://tinyurl.com/jkvtj6f>). The pile consists of 2,000 pairs of pairs of discs of tin foil glued to paper impregnated with Zinc sulphate and coated on the other side with manganese dioxide: 2,000 thin batteries in series. The operation of battery gradually leads to the oxidation of Zinc and the loss of manganese dioxide but the process takes place very slowly. One might actually wonder whether it takes place too slowly so that some other source of energy than the electrostatic energy of the battery would be keep the clock running. Karpen pile is analogous battery discover by Vasily Karpen (see <http://www.greenoptimistic.com/karpen-pile/#.V9JMiceHvJA>). It has now worked for 50 years.

Cold fusion is associated with electrolysis. Could the functioning of this mystery clock involve cold fusion taken seriously even by American Physical Society thanks to the work of the group of prof. Holmlid. Electrolytes have of course been "understood" for aeons. Ionization leads to charge

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

#### 6.4.2 What batteries are?

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

1. Battery (see <http://tinyurl.com/8xqsab>) consists of two distinct electrochemical cells (see <http://tinyurl.com/jq81jmo>). Cell consists of electrode and electrolyte. The electrodes are called anode and catode. By definition electron current along external wire flows to catode and leaves anode.
2. There are also ionic currents flowing inside the battery. In absence of the ionic currents the electrodes of the battery lose their charge. In the loading the electrodes get their charges. In the ideal situation the ionic current is same as electron current and the battery does not lose its charging. Chemical reactions are however taking place near and at the electrodes and in their reversals take place during charging. Chemical changes are not completely reversible so that the lifetime of the battery is finite.

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

3. The charge of the electrochemical cell is in the electrolyte near the surface of the electrode rather than inside it as one might first think and the chemical processes involve neutralization of ion and the transfer of neutral outcome to or from the electrode.
4. Catode - or better, the electrochemical cell containing the catode - can have both signs of charge. For positive charge one has a battery liberating energy as the electron current connecting the negative and positive poles goes through the load, such as LED. For negative charge current flows only if there is external energy feed: this is loading of the battery. External voltage source and thus energy is needed to drive the negative charges and positive charges to the electrodes. The chemical reactions involved can be rather complex and proceed in reverse direction during the loading process. Travel phone battery is a familiar example.

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

#### 6.4.3 Could dark cold fusion make possible self-loading batteries?

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

1. The battery is series of very many simpler batteries. The mechanism should reduce to the level of single building brick. This is assumed in the following.
2. The charge of the battery tends to be reduced unless the ionic and electronic currents are identical. Also chemical changes occur. The mechanism involved should oppose the reduction of the charging by creating positive charge to the catode and negative charge to the anode

or induce additional voltage between the electrodes of the battery inducing its loading. The energy feed involved might also change the direction of the basic chemical reactions as in the ordinary loading by raising the temperature at cathode or anode.

3. Could be formation of Pollack's exclusion zones (EZs) in the electrolytic cell containing the anode help to achieve this? EZs carry a high electronic charge. According to TGD based model protons are transformed to dark protons at magnetic flux tubes. If the positive dark charge at the flux tubes is transferred to the electrolytic cell containing cathode and transformed to ordinary charge, it would increase the positive charge of the cathode. The effect would be analogous to the loading of battery. The energy liberated in the process would compensate for the loss of charge energy due to electronic and ionic currents.
4. In the ordinary loading of the battery the voltage between batteries induces the reversal of the chemical processes occurring in the battery. This is due to the external energy feed. Could the energy feed from dark cold fusion induce similar effects now? For instance, could the energy liberated at the cathode as positively charged dark nuclei transform to ordinary ones raise the temperature and in this manner feed the energy needed to change the direction of the chemical reactions.

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

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

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

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

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

2. In the TGD inspired model for nerve pulse cell interior and cell exterior or at least their regions near to lipid layers are regarded as super-conductors forming a generalized Josephson junction. For the ordinary Josephson junction the Coulombic energy due to the membrane voltage defines Josephson energy. Now Josephson energy is replaced by the ordinary Josephson energy plus the difference of cyclotron energies of the ion at the two sides of the membrane. Also ordinary Josephson radiation can be generated. The Josephson currents are assumed to run along magnetic flux tubes connecting cell interior and exterior. This assumption receives support from the strange finding that the small quantal currents associated with the membrane remain essentially the same when the membrane is replaced with polymer membrane.
3. The model for Clarendon dry pile suggests an explanation for the self-loading ability. The electrolytic cell containing the anode corresponds to the negatively charged cell interior, where Pollack's EZs would be generated spontaneously and the feed of protonic charge to the outside of the membrane would be along flux tubes as dark protons to minimize dissipation. Also ions would flow along them. The dark protons driven to the outside of the membrane transform to ordinary ones or remain dark and flow spontaneously back and provide the energy needed to add phosphate to ADP to get ATP.
4. The system could be quantum critical in the sense that a small reduction of the membrane potential induces nerve pulse. Why the ability to generate Pollack's EZs in the interior would be lost for a few milliseconds during nerve pulse? The hint comes from the fact that

Pollack's EZs can be generated by feeding infrared radiation to a water bounded by gel. Also the ordinary Josephson radiation generated by cell membrane Josephson junction has energy in infrared range!

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

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

5. This model could also allow to understand the effect of anesthetes [K28] [L9]. Anesthetes could basically induce hyperpolarization so that Josephson photons would continually generate Pollack's EZ:s and creating of dark particles at the magnetic flux tubes. This need not mean that consciousness is lost at the cell level. Only sensory and motor actions are prevented because nerve pulses are not possible. This prevents formation of sensory and motor mental images at our level of hierarchy.

Meyer-Overton correlation states that the effectiveness of the anesthetic correlates with its solubility to the lipid membrane. This is the case if the presence of anesthetic in the membrane induces hyperpolarization so that the energies of the photons of Josephson radiation would be higher than needed for the generation of EZs accompanied by magnetic flux tubes along which ionic Josephson currents would flow between cell interior and exterior. For these quantal currents evidence exists [K20]. In the case of battery these dark ions would flow from the cell containing anode to that containing cathode. For depolarization the energy of Josephson photons would be too low to allow the kicking off protons from hydrogen bonded pairs of water molecules so that EZs would not be created and self-loading would stop and nerve pulse would be generated.

## 7 Could Photosensitive Emulsions Make Dark Matter Visible?

The article "Possible detection of tachyon monopoles in photographic emulsions" by Keith Fredericks [H7] describes in detail ([http://restframe.com/downloads/tachyon\\_monopoles.pdf](http://restframe.com/downloads/tachyon_monopoles.pdf)) very interesting observations by him and also by many other researchers about strange tracks in photographic emulsions induced by various (probably) non-biological mechanisms and also by the exposure to human hands (touching by fingertips) as in the experiments of Fredericks. That the photographic emulsion itself consists of organic matter (say gelatin) might be of significance.

### 7.1 The Findings

The tracks have width between  $5\ \mu\text{m}$ - $110\ \mu\text{m}$  (horizontal) and  $5\ \mu\text{m}$ - $460\ \mu\text{m}$  (vertical). Even tracks of length up to at least 6.9 cm have been found. Tracks begin at some point and end abruptly. A given track can have both random and almost linear portions, regular periodic structures (figs 11 and 12), tracks can appear in swarms (**Fig. 24**), bundles (**Fig. 25**), and correlated pairs (**Fig. 16**), tracks can also split and recombine (**Fig. 32**) (here and below "Fig." refers to a figure of the article at [http://restframe.com/downloads/tachyon\\_monopoles.pdf](http://restframe.com/downloads/tachyon_monopoles.pdf)).

Tracks differ from tracks of known particles: the constant width of track implies that electrons are not in question. No delta rays (fast electrons caused by secondary ionization appearing as branches in the track) characteristic for ions are present. Unlike alpha particle tracks the tracks are not straight. In magnetic fields tracks have parabolic portions whereas ordinary charged particle move along spiral. The magnetic field needed to cause spiral structure for baryons should be by two orders of magnitude higher than in the experiments.

For particle physicist all these features - for instance constant width - strongly suggest pre-existing structures becoming visible for some reason. The pre-existing structure could of course correspond to something completely standard structures present in the emulsion. If one is ready to accept that biology involves new physics, it could be something more interesting.

Also evidence for cold fusion is reported by the group of Urutskoev [H3]. There is evidence for cold fusion in living matter [C1, C10]: the fact that the emulsion contains gelatin might relate to this. In [L2] a dark matter based mechanism of cold fusion allowing protons to overcome the Coulomb wall is discussed. Either dark protons or dark nuclei with much larger quantum size than usually would make this possible and protons could end up to the dark nuclei along dark flux tubes. In TGD inspired biology dark protons (large  $h_{eff}$ ) with scaled up Compton length of order atomic size are proposed to play key role since their states allow interpretation in terms of vertebrate genetic code [L2, K31].

## 7.2 The Importance Of Belief System

These structures could be something quite standard or not. This readiness to consider non-standard explanations depends on belief system.

1. In the belief system of standard physics these pre-existing structures would be organic material consisting of ordinary matter so that no new physics is involved. Probably it is easy to kill this hypothesis. If this can be done, the situation becomes really interesting.
2. In my own belief system they *could* correspond to dark matter structures made visible by some mechanism. The presence of human hands could induce this phenomenon in the experiments of Fredericks. If so we might be already considering remote interactions involving dark photons and magnetic flux tubes, whose images “tracks” would be.
3. The first guess is that these structures are in the emulsion. This need not be the case! They could be structures outside- say in human hands - sending dark photon beam absorbed by the small photosensitive crystals in the emulsion. A photograph of dark matter (say in the hands of sender) would be formed! One possibility is that tracks represent a photograph of the dark matter at the flux tubes of the magnetic body of the emulsion. This would be a variant for what Gariaev perhaps managed to achieve with camera: taking a photo of dark matter [K1] !
4. Unfortunately belief system becomes important also in second manner. The reductionistic belief system tells that the tracks must be something trivial. There cannot be new physics in scale of cell as we have read in text books. Therefore these tracks are not studied by professionals who could very easily find whether there is something really interesting involved.

Dark matter in TGD based belief system corresponds to a hierarchy of phases of ordinary matter with an effective value  $h_{eff}$  of Planck constant coming as integer multiple of ordinary Planck constant. This makes possible macroscopic quantum phases consisting of dark matter. The flux tubes could carry magnetic monopole flux but the magnetic charge would be topological (made possible by the non-trivial second homology of  $CP_2$  factor of the 8-D imbedding space containing space-times as surfaces) rather than Dirac type magnetic charge.

The TGD inspired identification of tracks could be as images of magnetic flux tubes or bundles of them containing dark matter defining one of the basic new physics elements in TGD based quantum biology. One can imagine two options for the identification of the tracks as “tracks”.

1. The primary structures are in the photo-sensitive emulsion.
2. The structures in photograph are photographs of dark matter in external world, say structures in human hands or human body or of dark matter at some magnetic body, say at the flux tubes of the magnetic body of the emulsion.

The fact that the tracks have been observed in experimental arrangements not involving exposure to human hands, indeed suggests that tracks represent photographs about parts of the magnetic body assignable to the emulsion. For this option the external source would serve only as the source of possibly dark photons.

This would imply a close analogy with the experiments of Peter Gariaev's group interpreted in TGD framework as photographing of the magnetic body of DNA sample [K1]. Also here one has an external source of light: the light would be transformed to dark photons in DNA sample, scatter from the dark charged particles at the flux tubes of the magnetic body of DNA sample, and return back transforming to ordinary light and generating the image in the photosensitive emulsion.

### 7.3 Why Not Tachyonic Monopoles?

The identification of the tracks as orbits of particles proposed by author and also by other experimentalists is to my opinion problematic for the reasons which I have already explained. The article of Fredericks lists further details which do not conform with the particle interpretation. A further proposal is that the particles are tachyonic magnetic monopoles. One motivation for the monopole hypothesis is the (unsuccessful) attempt to explain the parabolic shape of the tracks in external magnetic field.

To my view the interpretation as a tachyonic monopole - a notion introduced by Recami and Mignani [H9] (<http://link.springer.com/journal/11546>) - adopted in the article is theoretically problematic. Of course, if the tracks are actually pre-existing structures made visible by some mechanism, there is no need to postulate super-luminal propagation. To see the problem, one can start from a general formula relating energy, momentum and mass. One has

$$E^2 = p^2 + m^2 . \quad (7.1)$$

When  $m$  is imaginary as for tachyon so that one can write  $m = iM$ , one obtains

$$E^2 = p^2 - M^2 . \quad (7.2)$$

If  $E$  and  $p$  are assumed to be real as is done usually the condition  $E \geq 0$  and more generally the reality of  $E$  gives  $p \geq M$ . Tachyon cannot therefore be at rest and one cannot assign to it kinetic energy since tachyon at rest would have imaginary energy.

This has two implications.

1. The identification as tachyon and the conclusion  $p \ll M$  from experiments (see figure 34 for the relation between  $E$ ,  $p$  and  $m$  in various cases) is not consistent with  $p \geq M$ .
2. Recami and Mignani assign a kinetic energy to tachyon (formula 14). Unfortunately, this formula does not make sense if one accepts that  $E$  and  $p$  are real since one cannot assign to tachyon kinetic energy: the analogy of kinetic energy would be "kinetic momentum" defined as the difference of the actual momentum and minimal momentum  $p = M$  ( $p_{kin} = \sqrt{E^2 + M^2} - M \simeq E - M - M^2/2E$ ). As Fredericks notices, the behavior is not actually consistent with a motion of magnetic monopole in magnetic field. Parabolic orbits are in plane orthogonal to magnetic field rather than containing its direction vector ([http://restframe.com/downloads/tachyon\\_monopoles.pdf](http://restframe.com/downloads/tachyon_monopoles.pdf))!

### 7.4 Interpretation As Dark Matter Structures Becoming Visible In Presence Of Living Matter

As such the observations are extremely interesting. I cannot however believe that the tracks represent particles. To my opinion tachyonic monopole interpretation fails because it does not make sense to talk about kinetic energy of tachyon.

To me the complex structures of tracks very strongly suggest pre-existing structures becoming visible for some reason. Looking the shape of tracks brings to my mind linear structure such as protein molecules. They contain regular helical portions and denatured portions. Now the longitudinal scale is of course much longer. The transversal scale is that for cells. This is perhaps not too surprising since organic materials such as gelatin are involved. The flux tubes could carry magnetic monopole fluxes and in purely formal sense would thus be analogous to magnetic monopoles with space-like momentum in their direction - that is tachyonic monopoles. They would be however actually ordinary systems with non-tachyonic momentum.

The particles possibly causing the tracks cannot be electrically charged since in this case they would not have managed to reach the emulsion. There seems however to be an interaction with magnetic fields since the tracks are parabola. Urutskoev et al [H3] propose that tracks are caused by magnetic monopoles. Unfortunately, the predicted parabolic orbit would be in the plane containing the magnetic field lines: the situation is completely analogous to the parabolic motion of projectile in the Earth's gravitational field.

#### 7.4.1 “Tracks” as photographs of magnetic flux tubes?

Consider first the identification of “tracks” (for convenience I will drop the quotation marks in the sequel) as images of magnetic flux tubes.

1. The hypothesis that tracks are photographs of flux tubes explains the “track-ness”. In the Earth's magnetic field the thickness of flux tubes is by flux quantization of the same order of magnitude as the thickness of thickest tracks observed for single flux quantum. Flux tube hypothesis seems to be also consistent with the other strange properties of the “tracks”. In particular, the composition to random and smoothly curved portion would conform with the idea that also linear molecules are formed around templates defined by magnetic flux tubes.
2. The tracks have been observed to be created in several situations and it is not at all clear whether the exposure to hands in the experiments of Fredericks is absolutely necessary. TGD suggests that the analog of dielectric breakdown associated with nerve pulses (the electric field at cell membrane is two times higher than the electric field inducing di-electric breakdown in air) replaces the strong electric fields causing di-electric breakdown used in the experiments of Urutskoev [H3]. Dark magnetic flux tubes can accompany any kind of matter so that tracks could be also images about the dark magnetic body of an external object rather than that of emulsion. In principle, one cannot exclude the possibility that the presence of the experimenter is decisive in all cases. If so, this would be a new kind of experimenter effect.
3. To what could the abrupt ending of the track correspond in this picture? Magnetic flux tubes cannot end but they can go to another space-time sheet through wormhole contact and apparently disappear. This would indeed take place for the closed flux tubes representing elementary particles and carrying magnetic monopole flux. The flux tubes could quite generally carry a multiple of magnetic monopole flux. They would have rather large scale as compared to the  $CP_2$  scale of  $10^4$  Planck lengths.

##### 1. Explanation for parabolic portions of tracks

The presence of parabolic tracks in the plane orthogonal to the external static magnetic fields is very interesting feature to be explained. Parabolic character could be simply due to the simplest non-linear fit to the shape of the flux tube: it is however argued that parabolic character is exact. One should understand why the flux tube is orthogonal to the external magnetic field or magnetic field generated by the emulsion? Could this reflect the geometry of the experimental arrangement?

In TGD framework one can consider a very natural possibility that a constant electric field orthogonal to the external magnetic field is present.

1. In standard physics the presence of the electric field might be excluded easily. In TGD framework simplest space-time sheets representing constant Kähler magnetic fields allow a simple deformation to sheets containing orthogonal electric field. A simple situation (not necessarily a preferred extremal of Kähler action) corresponds to a space-time sheet  $X^4 \subset M^4 \times S^2$ ,  $S^2$  a geodesic sphere of  $CP_2$ . Using spherical coordinates ( $u = \cos(\Theta)$ ,  $\Phi$ ) for  $S^2$  and Cartesian coordinates ( $t, z, x, y$ ) for  $M^4$ , one has ( $u = f(x), \Phi = \omega t + ky$ ) ( $c = 1$ ). The non-vanishing components of magnetic and electric fields are apart from a coefficient of proportionality of order unity given by  $E_x \equiv J_{0x} = \partial_x u \times \omega$  and  $B^z \equiv J_{xy} = \partial_x u \times k$  with  $E_x/B_z = \omega/k$ . Electric and magnetic fields are orthogonal and the value of the  $\omega/k$  ratio fixes the electric field strength in terms of the magnetic field strength. In fact, the mere assumption that the  $CP_2$  projection is 2-dimensional implies that electric and magnetic parts of various induced gauge fields are orthogonal.



2. This field would be represented by a space-time sheet at which the flux tubes of the external magnetic are topologically condensed (glued by wormhole contacts). The charged particles inside the flux tube would experience the presence of this electric field as a constant force trying to force them out from the flux tube. If the flux tube adopts a parabolic shape of the orbit of individual charged particle, the electric force is parallel to the flux tube and one has equilibrium situation. *All* charged particles inside flux tube must move with the same velocity at given point of flux tube: this conforms with super-conductivity implying the existence of global order parameter. Note that the dark charged particles inside flux tube would not directly interact with the emulsion or with air so that they can reach the emulsion easily.
3. For non-relativistic motion the equation for the parabolic orbit is  $y = x^2/L$ , where the length  $L = 2mv^2/qE$  characterizes the size scale of the parabola. Parametrizing  $E$  in terms of voltage and length  $L$  as  $E = V_e/L$  one has  $eV_c/mc^2 = 2(v/c)^2$ . For electron rest energy  $m_e c^2 = .5 \text{ MeV}$  and  $v/c = 10^{-3}$  one would have  $V_c = 1 \text{ V}$ . For proton the electric field would be by a factor  $2^{11}$  stronger for the same orbit parameters.

For a given electric field the parameters of the parabola allow to distinguish between flux tubes carrying different charged particles since the kinetic energies from the are expected to be different. I have indeed proposed that magnetic flux tubes could serve as a kind of filter allowing to distill ions with different masses at their own magnetic flux tubes: the equilibrium condition would make the flux tubes filters. The cyclotron energy scale  $E_c = \hbar_{eff} ZeB/m$  would give a rough guess for the order of magnitude of kinetic energy of the particle: cyclotron energy scale is proportional to  $\hbar_{eff}$  so that quite high energies can be considered. eV as a typical atomic energy scale and also as the energy scale of bio-photons (interpreted as decay products of dark photons [K30] ) is the first guess for the energy scale.

4. It should be easy to check whether the emulsion is accompanied by electric field and also to deduce bounds for its values. Living matter is electret and one could imagine that gelatin contains some kind of remnants of bio-electric fields - perhaps as dark variants.

#### 2. The decrease of the track thickness with the increase of distance

Urutskoev et al [H3] have reported the decrease of the track thickness with the increase of the source distance. Does this mean that the flux tubes photographed are near the source and the reduction of track thickness with distance is an optical effect similar to that for ordinary photographs?

If the flux tubes belong to the magnetic body of emulsion, this explanation fails. It is however easy to invent plausible explanation also in this case. based on a simple model for the quantization of the magnetic flux.

1. The reconnection for flux tubes of the source and emulsion can take place only for flux tubes with same magnetic field strength and by flux conservation same transversal area  $S$ . Note that conservation of magnetic flux implies  $B \times S = \text{constant}$  so that increasing the thickness of flux tube decreases the strength of the magnetic field.
2. If the flux tubes have a fractal structure with flux tubes containing bundles of flux tubes (bundle structure has been observed for the tracks), one can argue that the weaker the magnetic field, the smaller the number of flux tubes in the typical bundle and the smaller the radius of the bundle if the flux tubes inside bundle have constant density. For dipole field the weakening of the average field with distance could mean that flux tube bundles split to smaller bundles. A “temporary” splitting of at track to a bundle of widely separated tracks has been observed for tracks and would mean reduction of the average magnetic field strength.
3. If the number of grains corresponds to the number of flux tubes within a bundle, the number of flux tubes in the bundle would be thousands. The average size of the grain suggests a diameter of order  $.34 \mu \text{ m}$  for the flux tubes. If the magnetic length  $L_B = \sqrt{\hbar/eB}$  equals to  $L_B = .17 \mu \text{ m}$  (scaling rule: 1 Tesla corresponds to  $L_B = 64 \text{ nm}$ ), the magnetic field strength

would be 354 Gauss (the Earth's magnetic field has nominal value of 5 Gauss). The external magnetic field of 20 Gauss used by Urutskoev et al defines a good candidate for the flux tube radius. For this field single flux tube would correspond to 18-19 crystals.

If this model is on correct track, these photographs could among other things provide means for the detailed study of the quantized dynamics of magnetic fields based on decomposition to flux tubes consisting of flux tubes consisting of...

#### 7.4.2 What could be the source of dark photons?

Photographic emulsion would work as usually by detecting photons. What is clear that the photons must be dark when they scatter from the magnetic flux tubes of the magnetic body of the emulsion. There are however several options for how the dark photons are produced.

1. Ordinary photons from the source could hit the emulsion, transform to dark photons and propagate to the magnetic flux tubes, reflect back, transform to ordinary photons, and interact with the micro-crystals of the emulsion and generate the visible track as the image of the flux tube. Emulsion would take the role possessed by DNA sample in Gariaev's experiments and the external source would take the role of lamps used to generate visible light [K1].
2. Dark photons could also originate from the source. They could arrive along the flux tubes of its magnetic body. In the experimental situations considered these would reconnect with the flux tubes of the magnetic body of the emulsion and scatter from dark matter at them. After this the photons would propagate to the emulsion and transform to ordinary photons and give rise to the image. Reconnection of the flux tubes is the basic mechanism of attention in TGD inspired theory of consciousness and in TGD inspired biology, and also used to explain various findings of Persinger et al [K31].
3. The emission of dark photons is expected to take place in critical systems in which large values of effective Planck constant  $h_{eff}$  making possible long range correlations can be present. The situations studied (glow discharge plasma processes, exploding wires and foils, low energy discharges in water, super-compression of solid targets using electron beams) indeed seem to be critical. Only the search of monopoles of solar origin at the north pole represents a situation in which criticality is not present in obvious manner (the measurement method might involve criticality to guarantee maximal sensitivity). This kind of situations would generate time varying magnetic fields, whose flux tubes could reconnect with the magnetic flux tubes assignable to the photographic emulsion. This in turn would make possible for dark photons to propagate from source to the emulsion. In some experiments also static magnetic fields are present.
4. What is interesting that the "cold currents" reported already by Tesla in his experiments involving di-electric breakdowns at surfaces of wires of coils could correspond to dark currents propagating along the magnetic flux tubes [L3] [L3]. Most of these experiments correspond to critical situations making possible the manifestation of otherwise hidden new physics. Whether one can see these manifestations of course depends on whether one believes on the reductionistic Bible or not.

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