Hen and egg problems of biology from TGD point of view

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Abstract

Biology has several hen and egg problems. What came first: DNA,RNA, amino-acids or proto-cell membrane? Did metabolism precede genetic code or vice versa? The stimulus leading to this article could have been the finding that organic molecules are formed in interstellar space at ultralow temperatures of few Kelvin in which chemistry should freeze completely. Therefore the formation of glycine peptides, which has been demonstrated in the laboratory, should be impossible.

The paradox disappears in the TGD framework as do also the hen and egg problems. Magnetic body carrying dark matter as $h_{eff} = nh_0$ phases allows a universal realization of genetic code and of the analogs of basic bio-molecules in terms of dark nucleon and dark photon triplets. Chemical realization emerged later and the question is whether they emerged simultaneously or whether there was some natural order for the chemical steps. The prebiotic form of metabolic machinery based on hydrogen bonds and dark protons emerged at the same time. A metabolism with metabolic energy quantum assignable electrons which corresponds to average energy of a photon of microwave background is predicted and shows itself via miniature potentials of the neuronal membrane.

Contents

1 Introduction

Biology has several hen and egg problems. What came first: DNA,RNA, amino-acids or proto-cell membrane? Did metabolism precede genetic code or vice versa? The stimulus leading to this article could have been the finding that organic molecules are formed in interstellar space at ultralow temperatures of few Kelvin in which chemistry should freeze completely. Therefore the formation of glycine peptides, which has been demonstrated in the laboratory by the group of Serge Krasnosutski in an environment simulating interstellar space at 10 K temperature [I2], should be impossible. In fact, all organic molecules should be absent in so low temperatures but it has been found that interstellar space contains organic molecules at few Kelvin temperatures, in particular amino acid glycine (`https://cutt.ly/HSYQPmP`) although the independent confirmation is lacking in this case.

What can one say about the hen egg problem and prebiotic period in the TGD framework? It is good to start by briefly summarizing the relevant ideas of the TGD inspired quantum biology. More detailed summaries can be found in various articles related to dark variant of biochemistry [L18, L2, L12], to dark realizations of genetic code [L1, L9, L6, L11, L17], and to the models for cell membrane as generalized Josephson junction [K3, K1, K4, L10], of Pollack effect [**?**, **?**] and of water memory and morphogenesis [K2] [L16].

1. The basic notion is magnetic body (MB) carrying dark matter as $h_{eff} = nh_0$ phases of the ordinary matter and behaving quantum coherently in length scale proportional to h_{eff}. MB would control biomatter.

   Communications to MB, sensory input, would be in terms of generalized dark Josephson radiation from the cell membrane and the control by MB in terms of dark cyclotron radiation. The sensory input would be from the entire cell membrane and induced by the attachment of the ligands to the receptors.

2. The notion of a magnetic body having flux tubes as body parts leads to a model of bio-catalysis in which molecules are replaced with nodes of flux tube network. Molecules can find each other as part of this dynamical network involving reconnection of U-shaped flux tubes and their shortening in a reduction of h_{eff} liberating energy making to overcome the potential wall making the reaction low.

Dark photon and dark nucleon triplets provide a realization of genetic code [L1, L6, L9, L17]. The states of dark nucleon triplets provide also a realization of basic bio-molecules.

1. Z_6, Z_4, and $Z_{2,rot}$ or $Z_{2,refl}$ act as symmetry groups for the 3 icosahedral Hamiltonian cycles. Each cycle, one of type XZ_6, one of type Z_4, and one of type Z_2, defines 12-note scale and 20 3-chords identified as icosahedral faces and DNA codons. The notes along the cycle are obtained as a quint cycle, that is by scaling the frequency of the note by factor 3/2 at each edge of the oriented cycle.

   The orbits of faces under Z_n are assigned with amino-acids (AAs). This assumption has a concrete interpretation in terms of the resonance mechanism for bio-communications [L17].

   This gives 60 3-chords and the numbers of triangles at the orbits of triangles and the numbers of triangles at orbits correspond nicely to the numbers of DNA codons coding for AAs. 4 codons are however missing. The fusion with a unique tetrahedral code gives 64 chords and a dark 3-photon realization of the genetic code.

   Also the identification of DtRNA, dtRNA, and DAA in terms of icosahedral code is possible as found quite recently [L17]. Also the dark realization of genetic codons in terms of dark proton triplets allows this.

2. Z_6 allows unique icosahedral harmony defined by 12-note scale realized as an icosahedral Hamiltonian cycle. The corresponding AAs correspond to 3 DNA 6-plets and one DNA 2-plet. Z_4 corresponds to 2 bioharmomies with 5 amino-acids which correspond to DNA 4-plets. $Z_{2,rot}$ and $Z_{2,refl}$ correspond to 10 2-plets both. $Z_{2,rot}$ corresponds to 3 icosahedral harmonies and $Z_{2,refl}$ to 5 icosahedral harmonies. This makes $1 \times 2 \times (3 + 5) = 16$ bio-harmonies if the common key of the 12-note scale for the 3 icosahedral harmonies does

not matter and the orientation of the Hamiltonian cycle does not matter. One can also consider the possibility that the key and the orientation of the cycle for the 3 icosahedral harmonies matter. The change of the orientation replaces the quint cycle with a quart cycle (CG corresponds to quint and CF to quart).

3. The interpretation of bioharmonies is as correlates for moods, emotional states. There is evidence for this interpretation from the strange finding that RNA is able to transmit conditioning based on negative or positive emotions generated by stimulus (`https://cutt.ly/6SuLNqk`) discussed in the TGD framework in [L5, L7]. The interpretation would be that DRNA represents the effect of stimulus by its bio-harmony characterizing emotional state, and can induce molecular emotional expression in DDNA-DNA pairing and also in DAA-AA pairing and DX-X pairing in general.

   DX-X pairing by energy resonance mechanism would correspond to emotional expression. Something in X would depend on bio-harmony. In the case of DNA and RNA this something could be the methylation state and its analogs so that there would be a direct connection with epigenesis. Epigenesis would realize the dynamics of emotional expression.

The paradox created by the existence of organic molecules in interstellar space at temperatures of few Kelbin and the findings of Krasnosutski's group [I2] disappears in the TGD framework as do also the hen and egg problems. Magnetic body carrying dark matter as $h_{eff} = nh_0$ phases allows a universal realization of genetic code and of the analogs of basic bio-molecules in terms of dark nucleon and dark photon triplets. Chemical realization emerged later and the question is whether they emerged simultaneously or whether there was some natural order for the chemical steps. The prebiotic form of metabolic machinery based on hydrogen bonds and dark protons emerged at the same time. A new kind of metabolism with metabolic energy quantum assignable to electrons instead of protons is predicted. The metabolic energy quantum corresponds to the typical energy of a photon of microwave background. The miniature potentials of the neuronal membrane have this magnitude.

2 Hen egg problem, dark biomolecules, and resonance mechanism

The notions of magnetic body, dark matter as $h_{eff} = nh_0$ phases, dark analogs of information molecules, and resonance mechanism could allow a solution to the hen egg problem of biology: which came first, DNA, RNA, AAs or proto-cell membrane. I have considered the hen egg problem in [K8] and proposed a model of proto-cell in [L8].

Hen egg problem usually means that something is missing from the conceptual picture and TGD based quantum biology suggests what this missing piece could be. The general solution of the problem in TGD would be that dark analogs of information molecules emerged first simultaneously as Galois confined states of dark proton-triplets and dark photon-triplets.

This made possible resonance communications and the basic recognition mechanism by 3-resonance for dark 3-photons. DX-X pairing was based on energy resonance and these composites were able to find each other by resonance. The reduction of h_{eff} for connecting flux tubes in their shortening liberated energy making it possible to overcome the potential wall preventing chemical reactions to occur. This is not as easy as it looks at first since metabolic energy is needed to build the valence bonds and metabolic machinery is absent in early life.

The challenge is to develop a more detailed picture around these basic ideas. I have already earlier considered several proposals for the first steps of the evolution of basic bio-molecules [K10, K11, K8] but without the recent, rather detailed, view about resonance mechanism combined with the notion of dark 3N-photons and 3N-nucleons as dark analogs of basic biomolecules [L17].

2.1 Did the DX-X pairing occur simultaneously for all basic biomolecules?

Consider first the pairing of basic information molecules X (DNA, RNA, tRNA codons and AAs). Their polymers are not considered in this section. The simplest vision is that the dark variants of basic biomolecules emerged by Pollack effect [I8, I9, I1, I11, I13] in water irradiated by solar light.

1. Pollack effect generated exclusion zones (EZs) as negatively charged regions. Part of protons were transferred to magnetic monopole flux tubes of MBs assignable to water clusters and created phases of water with a hexagonal lattice-like structure.

2. An attractive possibility is that the notion of hydrogen bonds generalizes. The monopole flux tubes could be accompanied by hydrogen bonds. This predicts a length scale hierarchy of hydrogen bonds implying long range quantum correlations in arbitrarily long scales and allowing to understand the strange thermodynamic anomalies of water. The length of the dark flux tube is proportional to h_{eff} as also the total energy consisting of Kähler magnetic and volume contribution.

3. Galois confinement as a universal bind mechanism would give rise to sequences of dark protons as bound states. The states of dark proton triplet correspond to DDNAs, DRNAs, DtRNAs and DAAs.

   The pairing of the dark analogs of biomolecules with ordinary biomolecules to form pairs DX-X gave rise to the observed basic biomolecules. DX-X pairing requires that the ordinary biomolecules have transition energies, which correspond to the cyclotron transition energies of DX for the value of h_{eff} considered. Ordinary cyclotron transitions and vibrational transitions are good candidates in this respect.

4. Energy resonance condition for the pairs gives powerful conditions and selects the allowed biomolecules. The selection has not been completely unique. In tRNA the third letter of the chemical codon paired with one of the 32 DtRNAs need not be an ordinary nucleotide and in some viruses adenosine (A) is replaced with 2-amino-adenine ("Z") [I6] (`https://cutt.ly/hSRBS0K`).

2.2 Did proto-cell and peptides emerge first?

It is not at all clear whether the dark variants of the polymers of basic bio-molecules can emerge spontaneously. The problem is that the formation of valence bonds requires energy. This forces us to consider the TGD counterparts of the usual purely chemical proposals in which basic building bricks DNA, RNA and AAs form polymers. Now one considers an analog of polymerization at the level of DDA, DRNA, and DAA.

The findings of Montagnier *et al* [I4, I3, I5] discussed from the TGD view point in [L16] suggests that remote DNA replication occurs in absence of DNA template but that the presence of DNA polymerase is necessary. Dark DNA sequences generated by remote replication would appear as a template. This suggests DDNA-DNA pairing could occur by polymerization and require the presence of enzymes and metabolic energy feed.

Could proteins (Ps) have served in the role of egg in the chemical sense in the TGD framework? Could the resonance mechanism together with the TGD view about bio-catalysis make it possible to generate DP-P pairs by a polymerization-like process using DP as a template?

1. The large h_{eff} between DP and P would be shortened in a given polymerization step. Energy would be liberated as the dark flux tube bond between DP and P is shortened. This energy should make it possible to overcome the potential wall preventing the formation of the peptide bond and also provide the energy of the peptide bond, which is about .08-.16 eV and considerably smaller than metabolic energy quantum about .5 eV.

2. The thermal energy at room temperature using the definition $E_T = kT$ is .025 eV. Second definition of thermal energy is as the energy for which the distribution of black-body radiation as function of energy is maximum: this gives the energy is $E_T \simeq .12$ eV and rather near to the Josephson energy of the cell membrane for charge Z= 2e is about .1 eV.

3. The energetic requirements for AA polymerization might be satisfied by using irradiation with photon energy around thermal energy at room temperature. An interesting possibility considered in [K8] and [L8] is that a proto-cell membrane formed from lipids was present from the beginning and before the polymerization. Lipid membranes can form spontaneously and in TGD Universe they act as generalized Josephson junctions [K3, K4] and induce Josephson radiaton, which would make possible communications from cell membrane to MB. Could the

Josephson radiation from the cell membrane with energy of order .1 eV provide the metabolic energy for the polymerization process of AAs?

4. In the case of DNA and RNA the carbon bond energy between two codons is about 3.2 eV and considerably larger so that the polymerization without enzymes looks highly implausible. Note also that also the formation of lipids is a problem since C-C bonds have energy 3.47 eV.

2.3 Empirical and experimental support for the model of peptide formation

There is evidence for amino acid glycine in the interstellar space (`https://cutt.ly/HSYQPmP`) but the independent confirmation is lacking. Also the formation of glycine peptides has been observed in laboratory conditions mimicking the interstellar medium (ISM).

The following summarizes the results described in the article of Serge Krasnokutski *et al* [I2] published in Nature. The following summarizes Krasnosutski's non-technical description of the results (`https://cutt.ly/dSYm1Sn`).

1. The ultra-low temperatures, common in astrophysical environments, have been believed to freeze out any chemistry in the dense areas of the ISM. Already the discovery of a high abundance of small organic molecules in molecular clouds was a great surprise. But also the formation of amino acids, nucleobases, lipids, and sugars in space has been confirmed.

2. What about the polymers of AAs? It has been conjectured that the condensation of carbon atoms at the surface of dust particles make possible the formation of organic molecules. Serge Krasnokutski *et al* indeed demonstrated the formation of glycine polymers from amino ketenes (glycine corresponds NH_2-CH_2-COOH, aminoketene to NH_2-CH-CO and polyglycine to NH-CH_2-CO) under laboratory conditions simulating the ISM conditions at temperature T=10 K (`https://cutt.ly/3SYT169`). A spontaneous(!) formation of relatively short peptides (less than 10-11 monomeric units) was found. The polymerization of amino acids under energetic processing (e.g. heat, pressure, or UV irradiation) is known to occur. Therefore, a further increase in chain length can be expected in natural environments.

   Moreover, by adding other species instead of a proton to the α-carbon atom of amino ketene (nearest to the functional group) during the polymerization, a variety of different peptide chains can be formed. Furthermore, chemical and photochemical modifications of glycine residues in peptides into other amino acid residues were also demonstrated in many works. Thus, the glycine peptides observed in our experiments can be converted into different proteins.

3. These findings fit nicely with the proposed mechanism for the formation of proteins (or at least short peptides). The mechanism is not chemical, and no radiation is needed since the generalized Josephson radiation would provide the energy of the AA-AA bond, and the formation rate does not vanish at ultralow temperatures.

2.4 How did lipids, small organic molecules, and DNA and RNA polymers emerge?

There is a temptation to say that after the emergence of proto-cell membrane and peptides, the rest was history. This is not so simple.

1. The formation of the proto-cell membrane could occur spontaneously if lipids are available. Lipids however have C-C bonds with bond energy 3.47 eV and C==C bonds with energy 6.28 eV. These energies are in the UV range.

2. Also the energies of valence bonds associated with DNA, RNA, and also other basic biomolecules are in this range. The freezing of the chemistry at ultralow temperatures does not allow the generation of these bonds since the metabolic machinery provided by ATP molecules is not present. Simple organic molecules and even amino-acids are however detected in the interstellar medium. It seems that life-as-nothing-but-chemistry dogma must be wrong.

3. The Josephson radiation associated with proto-cell membrane with an energy scale of .1 eV could help in the formation of peptides but cannot help in the more general case. Could the splitting of a hydrogen bond provide the metabolic energy quantum of .5 eV in the absence of ATP machinery? The formation of water involving O-H bonds and their dynamics at temperatures of few K do not sound plausible unless one leaves the framework of the standard chemistry.

Metabolic machinery involves a lot of control and the standardization made possible by the metabolic energy quantum. This involves a lot of control. What could have served as a controller and energy source for bond formation at ultralow temperatures of few Kelvin and in the absence of the complex metabolic machinery based on ATP. In the TGD Universe, MB carrying dark matter is the answer to the question.

1. The existence of B_{end} was originally deduced by Blackman [J1] and other researchers. They found that ELF em fields had quantum-like effects on the vertebrate brain. These effects could be understood in terms of cyclotron transitions in the "endogenous" magnetic field $B_{end} \simeq 2B_E/5$ if the value h_{eff} of Planck constant was much larger than h, $h_{eff}/h \sim 10^{13}$ was required in order to scale the energy of 10 Hz photon to that of a visible photon with frequency 10^{14} Hz.

2. The large value of h_{eff} suggests its identification as gravitational Planck constant $\hbar_{eff} = \hbar_{gr} = GMm/v_0$ given by Nottale's hypothesis [E1]. M denotes here Earth's mass and m the mass of the charged particle. This predicts that cyclotron frequencies in B_{end} correspond to dark photon energies in the visible and UV UV range. Most remarkably, the energies do not depend on the mass m of charged particles. This realizes the Equivalence Principle.

3. Visible-UV energy range is associated also with biophotons [I10, I7] discussed from TGD view point in [K5, K6]. This motivates the identification of biophotons as decay products of dark photons or possibly even dark N-photons resulting in $h_{eff} \to h$ transition. Dark photons or N-photons in this energy. Note that the Nottale hypothesis and the notion of a monopole magnetic flux tube make sense only in the TGD Universe.

4. $h_{eff}/h_0 = n$ is identifiable as a dimension of extension of rationals in number theoretic vision about TGD. n serves as a kind of IQ [L3, L4]. MB with $h_{eff} = h_{gr}$ corresponds to a rather high level of number theoretic complexity assignable to the MB of Earth as a quantum system. MB has a long scale of quantum coherence - even of the order of the scale of Earth - and is by its high "IQ" the natural "boss" and controls the dynamics of the ordinary biomatter. The molecular transitions induced by the transformations of dark cyclotron (3N-)photons would serve as a natural control tool of MB. The cyclotron condensates at MB can provicde quantized metabolic currencies in the absence of ATP machinery.

5. MB could generate already at few Kelvin temperatures various biologically important molecules by providing the metabolic energy for the formation of various valence bonds, such as carbon and peptide bonds and make possible the formation of lipids, DNA and RNA molecules and their polymers and also other basic organic molecule. Josephson radiation would in turn make possible the generation of proteins. Gravitation would be a key player in living systems and play an especially important role in the very early stage. The chemistry at ultralow temperatures would provide a direct experimental handle to the biophysics associated with MB.

2.5 What can one say about pre-tRNA?

What could be the prebiotic counterpart of tRNA?

1. DtRNA should have a molecular counterpart. The simplest guess is that it corresponds to an RNA type codon appearing in tRNA but somehow differing from it. Pre-tRNA could simply be the (AAC-H)3' end of the acceptor stem with AAC replaced with XYZ, where ZYZ denotes the codon part of tRNA. The addition of a hydrogen atom would relate pre-tRNA codon to ordinary RNA codon.

2. The bond energy for the pre-tRNA-AA pair as the energy of the ester bond would be about .5 eV, which corresponds to the metabolic energy quantum. Energy is therefore required to "charge" pre-tRNA. This requires metabolic energy and in the absence of ATP machinery, the energy should come from its predecessor. What prebiotic metabolism could be, will be discussed in the next section.

3. If this step works, the polymerization of tRNAs involving the transformation of the ester bond of pre-tRNA-AA to AA-AA peptide bond can occur spontaneously since the peptide bond has bond energy of order .1 eV. This would give rise to polypeptides. This process would be like a translation process for RNA but without an RNA template and therefore the outcome would be random. Also the RNA polymerization in this manner can be considered, now however the RNA-RNA valence bond has considerably higher bond energy.

4. If DRNA-RNA sequences are formed, they might be transformed to AA sequences by pre-translation process using pre-tRNA and resonance mechanism pairing DRNAs and dark counterparts of pre-tRNA-AA pairs. This would define the pre-translation process.

2.6 What could the prebiotic metabolic machinery be?

Metabolic machinery should have a prebiotic counterpart and have energy about .5 eV as metabolic energy quantum.

1. Could the splitting of a hydrogen bond with bond energy about .5 eV provide the energy needed in the formation of pre-tRNA-AA ester bond? IR photons are most effective in causing Pollack effect in water: could also they induce pre-tRNA-AA pairing? Both options would require the presence of water. In principle, the proposed mechanism could lead to a generation of water molecules (the energy of O-H bond is 4.81 eV) already at temperatures of few Kelvin.

2. Could MB somehow provide the metabolic energy quantum? Gravitational flux tubes are in a central role in the TGD inspired quantum biology. In [L13] it was observed that the gravitational binding energy of a nucleon in the gravitational field of Earth is .67 eV. This is somewhat larger than the metabolic energy quantum. A dark proton at a distance of about $.34R_E$, R_E Earth radius, from the surface of Earth has gravitational binding energy of .5 eV.

   The bond energy of the hydrogen bond is .5 eV. Could it correspond to the reduction of the gravitational binding energy due to the delocalization of a dark proton to a gravitational flux tube? Could the hydrogen bond become dark gravitational U-shaped monopole flux tube with $h_{eff} = h_{gr}$ so that the proton of the ordinary hydrogen bond would become gravitationally dark? the size scale of Earth would define the length scale of this flux tube. The flux tube could however still connect the same atoms.

   The transformation $h_{gr} \to h$ induces a dramatic shortening of the U-shaped gravitatonal flux tube loop and the gravitationally dark proton at the gravitational flux tube of MB transforms to an ordinary proton. This localization has interpretation as falling of the proton to the surface of Earth. Could the liberated energy have an interpretation as a ametabolic energy quantum?

   For a dark variant of hydrogen bond a gravitational flux tube between atoms should form a very long loop at which the gravitationally dark proton would reside. This kind of picture about dark flux tubes associated with gauge interactions has been suggested earlier. For instance, color flux tubes assignable to nuclear protons could extend to distances of the order of atomic size.

3. Phosphate is electronegative and forms hydrogen bonds. Phosphate ionization could be interpreted as a formation of a dark hydrogen bond. This would explain why phosphate ions have such a central role in metabolism. Effective ionization serves as the signature of the delocalization. Also other electronegative ions could play the role of phosphate and arsenite has done this in some bacterial systems (`https://cutt.ly/ZS1fznG`).

   The pre-biotic counterpart of metabolic machinery should have involved phosphate ions or some other electronegative ions forming dark hydrogen bonds.

4. Also the valence electrons of valence bonds can become dark by the lengthening of the valence bond to a U-shaped gravitational flux loop. For electrons the gravitational binding energy at height $.34R_E$ is about .25 meV and .5 meV for their Cooper pairsm. Note that .3 meV corresponds to the energy of photons in the microwave background.

   Could this define a second metabolic energy quantum important in scales by a factor $m_p/m_e \sim 2^{11}$ longer than nanoscale about 1 nm assignable to DNA. This is the length scale of the cell nucleus, microtubules and axons. Intriguingly, the minimal fluctuations of membrane potentials correspond to the so-called miniature end plate potentials .4 mV (`https://cutt.ly/HSJIn76`).

5. A gravitational valence bond, connecting a metal atom with an atom with an opposite valence, would lead to effective ionization of the metal atom. For instance, biologically important bosonic ions such as Ca^{++}, Mg^{++}, Fe^{++} and Zn++ associated with their oxides could correspond to effective ions like this.

   The signature would be a pairing with a neutral oxygen atom by a gravitational valence bond. I have introduced the notion of dark ion to explain the findings of Blackman [J1] and others and dark ion could correspond to this kind of pair. The original variant of the model assumed that the entire ion is dark, the later version assumed that the valence electron of free atom is dark, and the model consider here assumes that the valence bond is dark.

6. The effective ionization requires energy ΔE to compensate the increment of the gravitational potential energy given by $\Delta E = (\langle V_{gr}(R)\rangle - V_{gr}(R_E))$. Here $E_{gr}(R)$ is gravitational potential energy proton or electron, and R_E denotes the radius of Earth, and R is the distance of the point of flux tube from the center of Earth.

   This estimate neglects the kinetic energy of the dark particle at the flux loop. This assumption is not consistent with the localization near the top of the loop so that the estimate can serve only as a rough order of magnitude estimate.

7. The maximal value for ΔE for electron Cooper pair (dark Cooper pair is at infinite distance) corresponds to $V_{gr}(R_E) = .36$ meV to be compared with the energy scale .3 meV defined by the temperature of 3 K microwave background and to the value .4 meV of the miniature potential. This suggests that, in the case of the electron, the reduction of kinetic energy contributes more than 10 per cent to the ΔE.

   For a single dark proton one has $V_{gr}(R_E) \simeq .34$ eV, which is below the nominal value of the metabolic energy currency about .5 eV. If a single dark proton is involved, the reduction kinetic energy should contribute at least 32 per cent to ΔE.

   For a dark proton Cooper pair, one has the maximal value of $\Delta E = .68$ eV somewhat above the metabolic energy quantum. These findings support the idea that both proton and electron Cooper pairs give rise to metabolic energy quanta. The challenge would be to understand the mechanism for the formation of proton Cooper pairs.

8. The transformation of electrons and protons between ordinary and gravitationally dark states would be a key process of metabolism and biocatalysis. This conforms with the fact that proton and electron exchanges play a key role in biology. For instance, phosphorylation means that the receiving molecule gains phosphate, which can form gravitationally a dark hydrogen bond so that the system becomes metabolically active. This would correspond to the activation in bio-catalysis.

   DNA base pairs are connected by 2 (A-T) or 3 (G-C) hydrogen bonds. If these strands can appear as dark gravitational strands, the maximum of 2 (3) metabolic quanta could be liberated in A-T (G-C) pairs via a transformation to ordinary hydrogen bonds. Could this serve as a yet-unidentified source of metabolic energy in the replication and transcription?

9. In the same way, in a redox reaction, the electron donor is oxidized and the electron receiver is reduced. Reduced molecule gains the ability to have a gravitationally dark electron, and therefore becomes metabolically active in the electronic sense. Redox reaction would be the electronic counterpart for phosphorylation.

2.7 Could the metabolism of cilia and flagella rely on gravitationally dark electrons?

The recent work in TGD has led to considerable progress in the understanding of metabolism [L15] already discussed in the section **??**. The TGD based view about metabolism involves in an essential way quantum gravity.

The observation is that the gravitational binding energy of dark protons at Bohr orbits in Earth's gravitational field for $h_{eff} = h_{gr} = Gmm/v_0$ [E1] [K7, K9] [L13, L10] can correspond to metabolic energy quantum in good approximation. The proposal is that the transformation of protons of hydrogen bonds possible for electronegative atoms and occurring at least for phosphate generates gravitational dark protons. Their transformation would liberate metabolic energy quantum.

The prediction is that besides gravitationally dark protons also similar electrons define a metabolic energy currency relating to standard metabolic currency like cent to dollar. It is proposed that the electronic metabolic currency can be applied to the purely understood metabolism of cilia and flagella (`https://cutt.ly/WDkYZzx`). I attach the proposal below almost as such.

According to [I12] (`https://cutt.ly/EDkW2bu`) the recent measurements in sea urchin sperm (length ~ 50 μm long, diameter 0.2 μm) show that the energy consumed per flagellar beat corresponds to $\simeq 2 \times 10^5$ ATP molecules. There is no GTP inside cilium as in the case of axonal MTs (`https://cutt.ly/5DkYGB2`). It is difficult to understand how ATP machinery could provide the metabolic energy feed.

This motivates the question about whether local ciliary metabolism could rely on the transformation of valence electrons of some biologically important ions to dark electrons at the gravitational MB and vice versa? The reduction of h_{gr} for electrons would provide the metabolic energy related by a factor $m_e/m_p \simeq 2^{-11}$ to the ordinary. According [I12], about 4×10^8 gravitationally dark electrons would transform to ordinary ones in a single stroke of cilium.

Electronic metabolic energy quantum would relate like cent to dollar and make possible a more refined metabolism with fine tuning. Electronic metabolism could also be an essential part of ordinary metabolism.

Consider now the idea more quantitatively.

1. What could be the electronic analog of ATP machinery. All biologically important ions can be considered as effective ions with some valence electrons at gravitational MB. In particular, the bosonic ions Ca^{++}, Mg^{++}, Fe^{++} and Zn^{++} could have Bose-Einstein condensates of gravitationally dark Cooper pairs at the gravitational MB.

   Ca^{++} waves play a key role in cellular biology, Fe^{++} is essential for oxygen based metabolism, and Mg^{++} and Zn^{++} are important in bio-catalysis: for instance, ATP must bind to Mg ions in order to become active.

2. What could be the mechanism transforming valence electrons to dark electrons? This should happen for positively charged biologically important ions, in particular for the bosonic ions Ca^{++}, Mg^{++}, Fe^{++} and Zn^{++}. The consumption of metabolic energy would correspond to a de-ionization of dark ion Ca^{++} and this might make it possible to test the proposal. For instance, Ca^{++} could accompany ciliary waves.

Where could the energy for ionization come from?

1. This question is also encountered in the chemistry of electrolytes [L2]. It is very difficult to understand how the external electromagnetic potentials, which give rise to extremely weak electric fields in atomic scales, could lead to ionization. The acceleration of electrons in the electric field along dark flux tubes involves very small dissipation and can easily give rise to electron energies making ionization possible.

2. MTs have a longitudinal electric field which by the generalization of Maxwell's equations to many-sheeted space-time (in stationary situation potential difference is same for paths along different space-time sheets) gives rise to an electric field along the magnetic flux tubes. These flux tubes need not be gravitational.

By darkness, the dissipation rate is low. Could the acceleration along flux tubes, in particular MT flux tubes, lead to the ionization? Could the electret property of linear biomolecules quite generally serve for the purpose of generating electronic metabolic energy storages in this way?

3. Assuming opposite charges $\pm Z_{MT}$ at the ends of dark magnetic flux tube associated with the MT, one obtains a rough estimate. The length of the cilium is $L \leq .5 \times 10^{-4}$ m and its radius is $R \sim 2 \times 10^{-7}$ m. The estimate for the energy gained by a unit charge e as it travels through the ciliary MT is $E \sim Z_{MT} e^2 L/R^2 \simeq Z_{MT} \times 2.85$ eV. The valence electron energy for atomic number Z with principal quantum number n (giving the row of the Periodic Table) is $E \simeq (Z/n)^2 \times 13.6$ eV. The ionization condition would be $Z_{MT} \geq (Z^2/n^2) \times 13.6/2.85$. For the double ionization in the case of Ca^{++} with $Z = 20$ and $n = 3$ this would give $Z_{MT} \geq 212$.

2.8 Quantum gravitation in TGD inspired quantum biology

The theory of Penrose and Hameroff [J3] assigns to microtubules quantum gravity in Planck length scale. In the TGD Universe, one does just the opposite. The hierarchy of effective Planck constants assigns to quantum gravitation quantum coherence scale even in the scales of astrophysical objects.

2.8.1 The notion of gravitational magnetic body

The proposed picture allows us to reconsider a long-standing question relating to the notion of MB with an onion-like layered structure. What could this sentence mean quantitatively?

1. The 4-surfaces X^4 with 1-D CP_2 projection and 3-D M^4 projection having 2-D membrane as E^3 projection are good candidates for various membrane objects in TGD Universe [L14]. The E^3 projection is not a minimal surface although X^4 is, and this possible if the 1-D CP_2 projection is dynamical. The flux tubes of MB should be assignable to kind of membrane-like surface.

2. The gravitational MB could be a layered structure containing the Bohr orbits with Bohr radii $r_n \propto n^2$ of particles in the gravitational field of Earth. Particles with different masses would concentrate at the same orbits. One would have the shell structure of the ordinary atom. This notion generalizes also to other interactions and for them the values of h_{eff} would be much smaller.

3. Flux sheets with a cylindrical rotational symmetry containing the orbits can be considered. These surfaces should be realized as preferred extremals of the action and should be minimal surfaces in $H = M^4 \times CP_2$. As closed surfaces they cannot define minimal surfaces of the Euclidean 3-space E^3. Indeed, soap bubbles are not minimal surfaces but require a constant pressure difference between interior and exterior. The analog of pressure difference would be non-trivial and dynamic 1-D projection of 4-D surface to CP_2 [L14]. The liberation of metabolic energy quantum would be analogous to a transition of hydrogen atom to a lower energy state.

2.8.2 Cell membrane, nerve pulse and quantum gravitation

This picture makes it possible to formulate a more precise view about the model of cell membrane as a generalized Josephson junction for which the generalized Josephson energy for charge Ze is the sum $E_J = ZeV + \Delta E_c$ of ordinary Josephson energy ZeV and difference ΔE_c of dark cyclotron energies for the flux tubes at the two sides of the cell membrane having in general different strengths of magnetic field.

The model requires large h_{eff} in order that Josephson frequencies can correspond to frequencies in the EEG range. This justifies the assumption that dark ions have $h_{eff} = h_{gr}$. The ionization would be effective and caused by the transformation of protons of hydrogen bonds and valence electrons to dark charge carriers at the gravitational flux tubes.

The physical meaning of the criticality against the generation of nerve pulse for a critical membrane potential $eV_{cr} \simeq .05$ eV has remained open.

1. Since voltage gives rise to negative potential energy, it seems clear that there must be positive contribution to the energy and this could come from the reduction ΔE_{gr} of the gravitational potential energy due to the positive *resp.* effective ionization of atoms of metal atoms *resp.* electronegative atoms with hydrogen bonds.

   The reduction of the gravitational potential energy for electrons is fraction m_e/m_p from that for protons so that protonic contribution should dominate in the reduction of gravitational potential energy if dark electrons and protons correspond to the same shell of gravitational atom. The first guess is that the energy shell and thus the distance from the Earth's surface is the same.

   The parametrization of the reduction of the gravitational energy per atom and for the difference ΔE_c of cyclotron energies should in the standard picture correspond to a thermodynamical formulation using chemical potentials to fix the ion concentrations. The water has very special thermodynamic properties in the range between freezing and boiling points and anomalies are largest near physiological temperatures. This would be due to the presence of dark hydrogen bonds, which supports the view that the number of dark protons and electrons depends on temperature.

2. In the first approximation the negative Coulombic interaction energy for the cell membrane is given by $E_{Coul} = -Q_{tot}eV = -\sum_i N_i(out)Z_ieV$, where N_i is the number effective ions with charge Z_ie. The contribution of positive charges is negative since V corresponds to a negative net charge for the cell. The situation is stable for $|E_{Coul}| \geq |E_{Coul,cr}| = N_p\Delta E_{gr}$. The system becomes critical at $Q_{tot}eV_{cr} = N_p\Delta E_{gr}$. The value of the critical potential energy is given by $eV_{cr} = N_p\Delta E_{gr}/Q_{tot}$ and is roughly constant for a given neuron. This suggests that the ratio N_p/Q_{tot} characterizes the cell.

   Neurons and ordinary cells could differ in that ordinary cells are either subcritical or so overcritical that nerve pulses do not occur. Subcriticality looks the more plausible option. The emergence of the nervous system would mean the discovery of quantum criticality as a control tool of MB.

3. In the generation of the nerve pulse the dark protons and electrons become ordinary ones in the reduction $h_{gr} \to h_{eff} \leq\leq h_{gr}$ for them and the membrane potential changes sign. In ZEO this transition could correspond to BSFR inducing time reversal and change of membrane potential. The second BSFR would bring back the original situation and membrane potential would return to the over-critical value.

2.8.3 Microtubules and quantum gravitation

In the TGD Universe quantum gravitation would be associated with the cell membrane, in particular neuronal membrane. Quantum gravitation has been speculatively assigned with microtubules (MTs) rather than cellular or neuronal membranes. What is the situation in TGD?

1. Axonal MTss are highly critical systems, which continually change their lengths. The surface of MTs has one GDP per tubulin dimer and the ends of MT has GTPs so that there is a constant negative charge per unit length. The number of GTPs is larger at the second end so that there is an electric field along MT.

2. GTP$\leftrightarrow GDP$ process accompanies the variation of the length of the MT. The transformation of the protons assignable to the phosphate hydrogen bonds to gravitationally dark protons could be an essential element of the MT dynamics. The periods of increasing/decreasing MT length could be initiated by BSFR and would correspond to different arrows of time. The effective ionization affects the effective charge of the axonal interior and therefore of membrane potential. This suggests a strong correlation with the variation of axonal MT lengths and nerve pulse propagation.

   The propagation of nerve pulse through the myelinated sections of the axons, where ion transfer with cell exterior is not possible, is a mystery in the standard model. Without axonal MTs the nerve pulse propagation would not be possible. This could allow us to understand why various neuronal diseases involve a reduced MT stability [J2] (`https://cutt.ly/4DaF6qc`).

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