Quantum criticality and dark matter: part III

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June 3, 2021
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Abstract

Quantum criticality is one of the corner stone assumptions of TGD. The value of Kähler coupling strength fixes quantum TGD and is analogous to critical temperature. TGD Universe would be quantum critical. What does this mean is however far from obvious and I have pondered the notion repeatedly both from the point of view of mathematical description and phenomenology. Dark matter as a hierarchy of phases of ordinary matter labelled by the value of effective Planck constant h_{eff} following as prediction of adelic physics suggests a general approach to quantum criticality. In the third part of the chapter about quantum criticality biological applications are discussed.

1 Introduction

Quantum criticality is one of the corner stone assumptions of TGD. The value of Kähler coupling strength fixes quantum TGD and is analogous to critical temperature. TGD Universe would be quantum critical. What does this mean is however far from obvious and I have pondered the notion repeatedly both from the point of view of mathematical description and phenomenology [K6, K12].

1. Criticality is characterized by long range correlations and sensitivity to external perturbations and living systems define an excellent example of critical systems - even in the scale of populations since without sensitivity and long range correlations cultural evolution and society would not be possible. For a physicist with the conceptual tools of existing theoretical physics the recent information society in which the actions of people at different side of globe are highly correlated, should look like a miracle.

2. The hierarchy of Planck constants with dark matter identified as phases of ordinary matter with non-standard value $h_{eff} = n \times h$ of Planck constant is one of the "almost-predictions" of TGD is definitely something essentially new physics. The phase transition transforming ordinary matter to dark matter in this sense generates long range quantal correlations and even macroscopic quantum coherence.

   Finding of a universal mechanism generating dark matter have been a key challenge during last ten years. Could it be that criticality is always accompanied by the generation of dark matter? If this is the case, the recipe would be stupifuingly simple: create a critical system! Dark matter would be everywhere and we would have observed its effects for centuries! Magnetic flux tubes (possibly carrying monopole flux) define the space-time correlates for long range correlations at criticality and would carry the dark matter. They are indeed key players in TGD inspired quantum biology.

3. Change of symmetry is assigned with criticality as also conformal symmetry (in 2-D case). In TGD framework conformal symmetry is extended and infinite hierarchy of breakings of conformal symmetry so that a sub-algebras of various conformal algebras with conformal weights coming as integer multiples of integer n defining h_{eff} would occur.

4. Phase separation is what typically occurs at criticality and one should understand also this. The strengthening of this hypothesis with the assumption $h_{eff} = h_{gr}$, where $h_{gr} = GMm/v_0$ is is the gravitational Planck constant originally introduced by Nottale. In the formula v_0 has dimensions of velocity, and will be proposed to be determined by a condition relating the size of the system with mass M to the radius within which the wave function of particle m with $h_{eff} = h_{gr}$ is localized in the gravitational field of M.

5. The condition $h_{eff} = h_{gr}$ implies that the integer n in h_{eff} is proportional to the mass of particle. The implication is that particles with different masses reside at flux tubes with different Planck constant and separation of phases indeed occurs.

6. What is remarkable is that neither gravitational Compton length nor cyclotron energy spectrum depends on the mass of the particle. This universality could play key role in living matter. One can assign Planck constant also to other interactions such as electromagnetic interaction so that one would have $h_{em} = Z_1 Z_2 e^2/v_0$. The phase transition could take place when the perturbation series based on the coupling strength $\alpha = Z_1 Z_2 e^2/\hbar$ ceases to converge. In the new phase perturbation series would converge since the coupling strength is

proportional to $1/h_{eff}$. Hence criticality and separation into phases serve as criteria as one tries to see whether the earlier proposals for the mechanisms giving rise to large h_{eff} phases make sense. One can also check whether the systems to which large h_{eff} has been assigned are indeed critical.

The motivation for this work came from super-fluidity. Superfluids exhibit rather mysterious looking effects such as fountain effect and what looks like quantum coherence of superfluid containers, which should be classically isolated. These findings serve as a motivation for the proposal that genuine superfluid portion of superfluid corresponds to a large h_{eff} phase near criticality at least and that also in other phase transition like phenomena a phase transition to dark phase occurs near the vicinity.

1.1 Some applications to living Matter

Biology is full of critical systems and criticality makes living matter highly sensitive to the external perturbations, gives maximal richness of structure, and makes them quantum coherent in macroscopic scales. Therefore it is not difficult to invent examples. The basic problem is whether the criticality is associated only with the transitions between different systems or with the systems themselves.

1. Sols and gels are very important in biology. Sol is definition a micture solid grains and liquid (say blood of cell liquid). Gel involves fixed solid structure and liquid. Sol-gel phase transition of the cell fluid takes place when nerve pulse travels along axon leading to the expansion of the cell. Is the dark phase generated with the sol-gel transition or does it characterized sol. Perhaps the most logical interpretation is that it is involved with the phase transition.

2. Pollack's fourth phase of water resembles gel [L2]. Charge separation implying that the exclusion zones are negatively charged takes place. Charging takes place because part of protons goes to outside of EZ. TGD proposal is that protons go to magnetic flux tubes outside the region or to flux tubes which are considerably larger than EZ that most of their wave functions is located outside the EZ. Is fourth phase is permanently quantum critical? Or is the quantum criticality associated only with the transition so that magnetic flux tubes would carry protons but they would not be dark after the phase transition. EZs have a strange property that impurities flow out of them. Could the presence of dark flux tubes and $h_{eff} = h_{gr}$ forces the separation of particles with different masses?

3. The chirality selection of bio-molecules is a mystery from the point of view of standard physics. Large h_{eff} phase with so large value of Planck constant that the Compton length of weak bosons defines nanoscale, could explain this: weak bosons would be effectively massless and mediate long range interactions below the scaled up Compton scale. This phase transition could also force phases separation if $h_{gr} = h_{eff}$ holds true. If the masses of biomolecules with different handedness are slightly different also the values of h_{gr} would differ and the molecules would go to flux tubes with different value of h_{eff} - at least in the phase transition. The value of $\hbar_{gr} = GMm/v_0$ is in the range $10^{10} - 10^{11}$ for biomolecules so that the $\Delta n/n \simeq \Delta m/m \simeq 10^{-10} - 10^{-11}$ would be needed: this would correspond to an energy of eV which corresponds to the energy scale of bio-photons and visible light.

4. Neuronal membrane could be permanently a critical system since the membrane potential is slightly above the threshold for nerve pulse generation. Criticality might give rise to the dark magnetic flux tubes connecting lipids to the DNA nucleotides or codons assumed in the model of DNA as topological quantum computer. The braiding of the flux tubes would represent the effect of the nerve pulse patterns and would be generated by the 2-D flow of the lipids of the membrane forming a liquid crystal.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at `http://tgdtheory.fi/tgdglossary.pdf` [L1].

2 Basic notions and ideas

2.1 Worrying About The Consistency With The TGD Inspired Quantum Biology

The life of theoretician trying to be worth of his salt is full of worrying: it is always necessary to make internal consistency checks. One of the worries is whether the hypothesis $\hbar_{eff} = n \times \hbar = \hbar_{gr} = GMm/v_0$ is really consistent with TGD inspired quantum biology or has wishful thinking made its way to the arguments? More precisely, does the nominal value $B_{end} = .2 \times 10^{-4}$ Tesla of "endogenous" magnetic field suggested by the effects of ELF em fields on brain give electron cyclotron energy $E = h_{eff}eB_{end}/2\pi m$ in few eV range for the value of n in question?

At the end of worry-filled section I have included two pieces of reckless speculation as the final relief.

2.1.1 Some background

First some background.

1. The identification $h_{eff} = h_{gr}$, where h_{gr} is what I call gravitational Planck constant

$$h_{gr} = \frac{GMm}{2\pi v_0} = \frac{r_S m}{4\pi\beta_0} \quad , \quad \beta_0 = \frac{v_0}{c} \tag{2.1}$$

   makes the model quantitive. In the expression of h_{gr} M is the "large" mass - naturally Earth's mass M_E. m would be the mass of ^4He atom. $r_S = 2GM/c$ denotes Schwartschild radius of Earth, which from $M_E = 3 \times 10^{-6} M_{Sun}$ and from $r_S(Sun) = 3$ km is 4.5 mm. v_0 would be some characteristic velocity for Earth-superfluid system and the rotation velocity $v_0 = 465.1$ m/s of Earth is a good candidate in this respect. Also the radius of Earth $R_E = 6.38 \times 10^6$ meters will be needed.

2. One could fix the value of v_0 in the following manner. Consider the Schrödinger equation for particle in gravitational field of a massive object at vertical flux tubes carrying the gravitational interaction. The solutions are Airy functions which decay very fast above some critical distance z_0. Require that z_0 is apart from a numerical factor equal to Earth radius. This condition predicts the value of v_0 which is consistent in the case of Earth and Sun with earlier hypothesis about their values. For Sun v_0 would be 5.65×10^{-4}c and for Earth orbital rotation velocity β_0 scaled up from 1.6×10^{-6} to 2.3×10^{-6} by a factor $1.41 \simeq \sqrt{2}$.

3. In TGD inspired biology the hypothesis $h_{gr} = h_{eff} = n \times h$ plays a key role. One of the basic implications is that the energies of cyclotron photons associated with magnetic flux tubes have universal energy spectrum since the dependence on the mass of the charged particle disappears. Also the gravitational Compton length. The gravitational Compton length $\lambda_{gr} = h_{gr}/m$ does not depend on the mass of the particle and equals to $\lambda_{gr} = GM/v_0 \simeq 645$ meters in the recent case. The scale of the superfluid system is thus much smaller than the coherence length.

4. Note that the nominal value of B_{end} is definitely not the only value in the spectrum of B_{end}. Already the model of hearing forces to allowing spectrum of about 10 octaves (3 orders of magnitude) corresponding the spectrum of audible frequencies. Also the geometric model of harmony correlating music and genetic code requires this.

2.1.2 Does $h_{gr} = h_{eff}$ hypothesis predict that the energy range of dark photons is that of biophotons?

Consider now the question whether the predicted value of n is consistent with the assumption that dark cyclotron photons have energies in visibleandUV range.

1. The value of integer n in $h_{eff} = n \times n$ equals to the ratio of gravitational and ordinary Compton lengths

$$n = \frac{h_{eff}}{h} = \frac{\lambda_{gr}}{\lambda_c} \quad .$$

For electron one obtains $n = .6 \times 10^{15}$. In the case of proton the frequency the ratio would be by a factor about 2×10^3 higher.

The value of n is much higher than the lower bound $10^9/6$ given as the ratio of visible photon frequency about 10^{14} Hz and cyclotron frequency $f = 6 \times 10^5$ Hz of electron in the magnetic field having the nominal value $B_{end} = .2$ Gauss of endogenous magnetic field. The discrepancy is six orders of magnitude. Desired value would be correspond to magnetic field strengths of order B_{end} in $B_{gal} = 1$ nT range which corresponds to the order of magnitude for galactic magnetic fields.

The value of n would give for B_{end} and an ion with 10 Hz cyclotron frequency (say Fe^{++} ion) energy of visible photon. The condition $\frac{h_{eff}}{h}$ predicts a value which is at least by a factor $m_p/m_e \simeq 2^{11}$ higher and one must also now assume galactic magnetic field strength to obtain a sensible result.

2. The naïve expectation was that $B_{end} = .2 \times 10^{-4}$ Tesla should give energy in few eV range. Something goes definitely wrong since the magnetic fields in this value range should be in key role. Either the hypothesis $h_{eff} = h_{gr}$ is wrong or the model is somehow wrong.

3. It is of course very naïve to assume that only single value of magnetic field is important. In fact, precognitve events are found to occur most frequently almost in the middle of sideral day which could be explained as being due to the involvement of galactic magnetic field.

2.1.3 Should one modify the $h_{gr} = h_{eff}$ hypothesis?

If one wants bio-photon spectrum to be in visible-UV range assuming that bio-photons correspond to cyclotron photons, one must reduce the value of $r = h_{gr}B_{end}/mv_0$ for Earth particle system by a factor of order $k = 2 \times 10^{-4}$. r does not depend on the mass of the charged particle. One can replace B_{end} with some other magnetic field having value which is considerably smaller. One can also increase the value of v_0.

1. For h_{gr} determined by Earth's mass and $v_0 = v_{rot}$, where $v_{rot} \simeq 1.55 \times 10^{-6}c$ is the rotation velocity of Earth around its axis and for $B_{end} \to B_{gal} = 1$ nT, where B_{gal} is typical strength of galactic magnetic field, the energy of dark cyclotron energy is 45 eV (UV extends to 124 eV). This is roughly by a factor 50 higher than the lower bound for the range of bio-photon energies. One possibility is that B_{gal} defines the upper limit of the dark photon energies and has variation range of at least 7 octaves with lower limit roughly 1/50 nT.

   One can also consider the possibility B_{gal} defines lower bound for the magnetic field strengths involved and one has $v_0 > v_{rot}$. For sun the rotation velocity at Equator is $v_{rot} = 2 \times 10^{-5}$ m/s and v_0 is $v_0 \simeq 5.8 \times 10^{-4}c$. One has $v_0/v_{rot} \simeq 29.0$. If same is true in case of Earth, the value of the energy comes down from 25 eV to 1.6 eV which corresponds to visible wave length.

   The assignment of B_{gal} to gravitational flux tubes is very natural. Now however the frequencies of dark variants of bio-photons would not be in EEG range: 10 Hz frequency would correspond to 5×10^{-4} Hz with period of 42 min. The time scale of 42 min is however very natural concerning consciousness and could be involved with longer bio-rhythms. Scaled EEG spectrum with alpha band around 46 min naturally assignable to diurnal sub-rhythms could be a testable prediction. Natural time would be sidereal (galactic) time with slightly different length of day and this allows a clear test. Recall the mysterious looking finding of Spottiswoode that precognition seems to be enhanced at certain time of sidereal day [J2]. Cyclotron frequency 1 Hz would correspond to 7 hours. One can ask whether 12 hours (25) is the natural counterpart for the cyclotron frequency 1 Hz assignable to DNA. This would correspond to lower bound $B_{gal} \to 7B_{gal}/12 \simeq .58$ nT or to $v_0 \to 1.7v_0$.

2. The idea has been that it is dark EEG photons, which correspond to bio-photons. Could one assign bio-photons also to dark EEG so that magnetic fields of Earth and galaxy would correspond to two different control levels? If $B_{end} = .2$ Gauss is assumed to determine the scale of the magnetic field associated with the flux tubes carrying gravitational flux tubes, one must reduce h_{gr}. The reduction could be due to $M \to M_D = kM$ and due to the change of v_0. k could characterize the dark matter portion of Earth but this assumption is not necessary.

   This would require $k = M_{dark,E}/M_E \simeq 5 \times 10^{-5}$ if one does not change the value of v_0. This value of k equals to the ratio of B_{gal}/B_{end} and would be 1/4:th of $k = 2 \times 10^{-4}$. One might argue that it is indeed dark matter to which the gravitational flux tubes with large value of Planck constant connect biomatter.

3. Suppose that one does not give up the idea that also Earth mass gives rise to h_{gr} and scaled analog of EEG. Then M_D must correspond to some mass distinguishable from and thus outside Earth. The simplest hypothesis is that a spherical layer around Earth is in question. TGD based model for spherical objects indeed predict layered structures [K28]. There are two separate anomalies in the solar system supporting the existence of a spherical layer consisting of dark mass and with radius equal to the distance of Moon from Earth equal to 60.3 Earth radii [K27]. The first anomaly is so called Flyby anomaly and second one involves a periodic variation of both the value of the measured Newton's constant at the surface of Earth and of the length of the day. The period is about 6 years and TGD predicts it correctly.

   One can imagine that dark particles reside at the flux tubes connecting diametrically opposite points of the spherical layer. Particles would experience the sum of gravitational forces summing up to zero in the center of Earth. Although the layer would be almost invisible (or completely invisible by argument utilizing the analogy with conducting shell) gravitationally in its interior, $h_{gr} = M_D m/v_0$ would make itself visible in the dynamics of dark particles! This layer could represent magnetic Mother Gaia and EEG would take care of communications to this layer.

   The rotation velocity $v_{rot,M} \simeq 2.1 \times v_{rot,E}$ of Moon around its axis is the first guess for the parameter v_0 identifiable perhaps as rotation velocity of the spherical layer. A better guess is that the ratio $r = v_0/v_{rot,M}$ is the same as for Sun and as assumed above for Earth. This would give for the ratio of cyclotron frequency scales $r = (B_{end}/B_{gal}) \times 2.1$. 66.7 min, which corresponds to $B_{gal} = .63$ nT, would correspond to .1 s. For this choice 1 Hz DNA cyclotron frequency would correspond 11.7 h rather near to 12 h. This encourages the hypothesis that 72 min is the counterpart of .1 s cyclotron time. The cyclotron time of DNA (very weakly dependent on the length of DNA double strand) in B_{gal} (or its minimum value) would be 12 h.

2.1.4 Did animal mitochondrial evolution have a long period of stagnation?

I encountered an interesting popular article (see `http://tinyurl.com/y9akruh`) telling about findings challenging Darwin's evolutionary theory. A technical representation can be found from the original article of Stoeckle and Thaler (see `http://tinyurl.com/ycsdc279`).

The conclusion of the article is that almost all animals, 9 out of 10 animal species on Earth today, including humans, would have emerged about 100,000 200,000 years ago. According to Wikipedia all animals are assumed to have emerged about 650 million years ago from a common ancestor. Cambrian explosion began around 542 million years ago and meant a sudden emergence of complex life from. What happened looks like a mystery. TGD based explanation involving TGD based new physics is discussed [K4]. According to Wikipedia Homo Sapiens would have emerged 300,000-800,000 years ago.

On basis of Darwin's theory based on survival of the fittest and adaptation to a new environment, one would expect that the species such as ants and humans with large populations distributed around the globe become genetically more diverse over time than the species living in the same environment. The study of so called neutral mutations not relevant for survival and assumed to occur with some constant rate however finds that this is not the case. The study of so called mitochondrial DNA barcodes across 100,000 species showed that the variation of neutral mutations

became very small about 100,000-200,000 years ago. One could say that the evolution differentiating between them began (or effectively began) after this time. As if mitochondrial clocks for these species would have been reset to zero at that time as the article states it This is taken as a support for the conclusion that all animals emerged about the same time as humans.

The proposal of (at least) the writer of popular article is that the life was almost wiped out by a great catastrophe and extraterrestrials could have helped to start the new beginning. This brings in mind Noah's Ark scenario. But can one argue that humans and the other animals emerged at that time: were they only survivors from a catastrophe. One can also argue that the rate of mitochondrial mutations increased dramatically for some reason at that time.

Could one think that great evolutionary leap initiating the differentiation of mitochondrial genomes at that time and that before it the differentiation was very slow for some reason? Why this change would have occurred simultaneously in almost all animals? Something should have happened to the mitochondria and what kind of external evolutionary pressure could have caused it?

1. To me the idea about ETs performing large scale genetic engineering does not sound very convincing. That only a small fraction of animals survived the catastrophe sounds more plausible idea. Was it great flood? One can argue that animals living in water would have survived in this case. Could some cosmic event such as nearby supernova have produced radiation killing most animals? But is mass extinction really necessary? Could some evolutionary pressure without extinction caused the apparent resetting of mitochondrial clock?

2. In TGD based quantum biology the great leaps could be caused by quantum criticality perhaps induced by some evolutionary pressure due to some kind of catastrophe. The value of $h_{eff} = nh_0$ (h_0 is the minimal value of Planck constant) - kind of IQ in very general sense - in some part of mitochondria could have increased and also its value would have fluctuated. Did a new longer length scale relevant to the functioning of mitochondrias emerge? Did the mitochondrial size increase? Here I meet the boundaries of my knowledge about evolutionary biology!

3. Forget for a moment the possibility of mass extinction. Could the rate of mutations, in particular the rate of neutral mutations, have increased as a response to evolutionary pressure? Just the increased ability to change helps to survive. This rate would become high at quantum criticality due to the presence of large quantum fluctuations (variations of h_{eff}). If the mitochondria were far from quantum quantum criticality before the catastrophe, the rate of mutations would have been very slow. Animal kingdom would have lived a period of stagnation. The emerging quantum criticality - forced by a catastrophe but not involving an extinction - could have increased the rate dramatically. This picture would provide formulation for the notion of punctuated equilibria in terms of quantum criticality.

2.1.5 An island at which body size shrinks

I encountered in Facebook an article claiming that the bodies of animals shrink at the island of Flores belonging to Indonesia (see `http://tinyurl.com/ycluutnql`). This news is not Dog's days news (Dog's days news is a direct translation from the finnish synonym for fake news).

Both animals and humans really are claimed to have shrinked in size. The bodies of both hominins (predecessors of humans, humans, ane even elephants) have shrinked at Flores.

1. In 2003, researchers discovered in a mountain cave in the island of Flores fossils of tiny, humanlike individual. It had chimp sized brain and was 90 cm tall. Several villages at the area are inhabited by people with average body height about 1.45 meters.

2. Could the small size of the recent humans at Flores be due to interbreeding between modern humans with Homo Florensiensis (HF) occurred long time ago? The hypothesis could be tested by studying the DNA of HF. Since the estimate age of fossils of HF was 10,000 years, researchers hoped that they could find some DNA to HF. DNA was not found but researchers realized that if HF as interbreeded with humans, this DNA could show itself in DNA of modern humans at Flores. It was found that this DNA can be identified but differs

insignificantly from that of modern humans. It was also found that the age of the fossils was about 60,000 years.

3. Therefore it seems that the interbreeding did not cause the reduction in size. The study also showed that at least twice in the ancient history of humans and their relatives arrived as Flores and then grew shorter [I10] (see `http://tinyurl.com/y9th5zne`). This happened also for elephants that arrived to Flores at twice.

This looks really weird! Weirdness in this proportion allows some totally irresponsible speculation.

1. The hierarchy of Planck constants $h_{eff} = nh_0$ ($h = 6h_0$ is a good guess [L9, L24, L8]) assigned with dark matter as phases of ordinary matter and responsible for macroscopic quantum coherence is central in TGD inspired biology. Quantum scales are proportional to or its power (h_{eff}^2 for atoms, h_{eff} for Compton length, and $h_{eff}^{1/2}$ for cyclotron states).

2. The value of gravitational Planck constant h_{gr} ($= h_{eff}$) at the flux tubes mediating gravitational interaction could determine the size scale of the animals. Could one consider a local anomaly in which the value of h_{gr} is reduced and leads to a shrinkage of also body size?

3. h_{gr} is of form $\hbar_{gr} = GM_Dm/v_0$, where v_0 a velocity parameter [K19, K26] [L23] (see `http://tinyurl.com/y8xhvwt2`, `http://tinyurl.com/yaattlzm`, and `http://tinyurl.com/y8vnyppq`). M_D is a large dark mass of order 10^{-4} times the mass of Earth. Gravitational Compton length $\Lambda_{gr} = h_{gr}/m = GM_D/v_0$ for a particle with mass m. $\Lambda_{gr} = h_{gr}/m$ does not depend on the mass of the particle - this conforms with Equivalence Principle. The estimate of [L23] gives $\Lambda_{gr} = 2\pi GM_D/v_0 = 2.9 \times r_S(E)$, where the Schwartshild radius of Earth is $r_S(E) = 2GM_E = .9$ mm. This gives $\Lambda_{gr} = 2.6$ mm, which corresponds to p-adic length scale $L(k = 187)$. Brain contains neuron blobs with this size scale. The size scale of organism is expected to be some not too large multiple of this scale.

   Could one think that v_0 at Flores is larger than normally and reduces the value of Λ_{gr} so that the size for the gravitational part of the magnetic body of any organism shrinks, and that this gradually leads to a reduction of the size of the biological body. Second possibility is that the value of dark mass M_D is at Flores smaller than elsewhere: one would have a dark analogy of ordinary local gravitational anomaly. The reduction of h_{gr} should be rather large so that the first option looks more plausible.

2.2 Why metabolism and what happens in bio-catalysis?

TGD view about dark matter gives also a strong grasp to metabolism and bio-catalysis - the key elements of biology.

2.2.1 Why metabolic energy is needed?

The simplest and at the same time most difficult question that innocent student can make about biology class is simple: "Why we must eat?". Or using more physics oriented language: "Why we must get metabolic energy?". The answer of the teacher might be that we do not eat to get energy but to get order. The stuff that we eat contains ordered energy: we eat order. But order in standard physics is lack of entropy, lack of disorder. Student could get nosy and argue that excretion produces the same outcome as eating but is not enough to survive.

We could go to a deeper level and ask why metabolic energy is needed in biochemistry. Suppose we do this in TGD Universe with dark matter identified as phases characterized by $h_{eff}/h = n$.

1. Why metabolic energy would be needed? Intuitive answer is that evolution requires it and that evolution corresponds to the increase of $n = h_{eff}/h$. To see the answer to the question, notice that the energy scale for the bound states of an atom is proportional to $1/h^2$ and for dark atom to $1/h_{eff}^2 \propto n^2$ (do not confuse this n with the integer n labelling the states of hydrogen atom!).

2. Dark atoms have smaller binding energies and their creation by a phase transition increasing the value of n demands a feed of energy - metabolic energy! If the metabolic energy feed stops, n is gradually reduced. System gets tired, loses consciousness, and eventually dies.

   What is remarkable that the scale of atomic binding energies decreases with n only in dimension $D = 3$. In other dimensions it increases and in $D = 4$ one cannot even speak of bound states! This can be easily found by a study of Schrödinger equation for the analog of hydrogen atom in various dimensions. Life based on metabolism seems to make sense only in spatial dimension $D = 3$. Note however that there are also other quantum states than atomic states with different dependence of energy on h_{eff}.

2.2.2 Conditions on bio-catalysis

Bio-catalysis is key mechanism of biology and its extreme efficacy remains to be understood. Enzymes are proteins and ribozymes RNA sequences acting as biocatalysts.

What catalysis demands?

1. Catalyst and reactants must find each other. How this could happen is very difficult to understand in standard biochemistry in which living matter is seen as soup of biomolecules. I have already already considered the mechanisms making it possible for the reactants to find each other. For instance, in the translation of mRNA to protein tRNA molecules must find their way to mRNA at ribosome. The proposal is that reconnection allowing U-shaped magnetic flux tubes to reconnect to a pair of flux tube connecting mRNA and tRNA molecule and reduction of the value of $h_{eff} = n \times h$ inducing reduction of the length of magnetic flux tube takes care of this step. This applies also to DNA transcription and DNA replication and bio-chemical reactions in general.

2. Catalyst must provide energy for the reactants (their number is typically two) to overcome the potential wall making the reaction rate very slow for energies around thermal energy. The TGD based model for the hydrino atom having larger binding energy than hydrogen atom claimed by Randell Mills [D4] suggests a solution [L9]. Some hydrogen atom in catalyst goes from (dark) hydrogen atom state to hydrino state (state with smaller h_{eff}/h and liberates the excess binding energy kicking the either reactant over the potential wall so that reaction can process. After the reaction the catalyst returns to the normal state and absorbs the binding energy.

3. In the reaction volume catalyst and reactants must be guided to correct places. The simplest model of catalysis relies on lock-and-key mechanism. The generalized Chladni mechanism forcing the reactants to a two-dimensional closed nodal surface is a natural candidate to consider. There are also additional conditions. For instance, the reactants must have correct orientation. For instance, the reactants must have correct orientation and this could be forced by the interaction with the em field of ME involved with Chladni mechanism.

4. One must have also a coherence of chemical reactions meaning that the reaction can occur in a large volume - say in different cell interiors - simultaneously. Here MB would induce the coherence by using MEs. Chladni mechanism might explain this if there is there is interference of forces caused by periodic standing waves themselves represented as pairs of MEs.

2.2.3 Phase transition reducing the value of $h_{eff}/h = n$ as a basic step in bio-catalysis

Hydrogen atom allows also large $h_{eff}/h = n$ variants with $n > 6$ with the scale of energy spectrum behaving as $(6/n)^2$ if the $n = 4$ holds true for visible matter. The reduction of n as the flux tube contracts would reduce n and liberate binding energy, which could be used to promote the catalysis.

The notion of high energy phosphate bond is somewhat mysterious concept and manifests as the ability provide energy in ATP to ADP transition. There are claims that there is no such bond. I have spent considerable amount of time to ponder this problem. Could phosphate contain (dark) hydrogen atom able to go to the a state with a smaller value of h_{eff}/h¡ and liberate the excess

binding energy? Could the phosphorylation of acceptor molecule transfer this dark atom associated with the phosphate of ATP to the acceptor molecule? Could the mysterious high energy phosphate bond correspond to the dark atom state. Metabolic energy would be needed to transform ADP to ATP and would generate dark atom.

Could solar light kick atoms into dark states and in this manner store metabolic energy? Could nutrients carry these dark atoms? Could this energy be liberated as the dark atoms return to ordinary states and be used to drive protons against potential gradient through ATP synthase analogous to a turbine of a power plant transforming ADP to ATP and reproducing the dark atom and thus the "high energy phosphate bond" in ATP? Can one see metabolism as transfer of dark atoms? Could possible negentropic entanglement disappear and emerge again after ADP$\rightarrow$ ATP.

Here it is essential that the energies of the hydrogen atom depend on $\hbar_{eff} = n \times h$ in as $\hbar_{eff}^m$, $m = -2 < 0$. Hydrogen atoms in dimension D have Coulomb potential behaving as $1/r^{D-2}$ from Gauss law and the Schrödinger equation predicts for $D \neq 4$ that the energies satisfy $E_n \propto (h_{eff}/h)^m$, $m = 2 + 4/(D-4)$. For $D = 4$ the formula breaks since in this case the dependence on $\hbar$ is not given by power law. m is negative only for $D = 3$ and one has $m = -2$. There $D = 3$ would be unique dimension in allowing the hydrino-like states making possible bio-catalysis and life in the proposed scenario.

It is also essential that the flux tubes are radial flux tubes in the Coulomb field of charged particle. This makes sense in many-sheeted space-time: electrons would be associated with a pair formed by flux tube and 3-D atom so that only part of electric flux would interact with the electron touching both space-time sheets. This would give the analog of Schrödinger equation in Coulomb potential restricted to the interior of the flux tube. The dimensional analysis for the 1-D Schrödinger equation with Coulomb potential would give also in this case $1/n^2$ dependence. Same applies to states localized to 2-D sheets with charged ion in the center. This kind of states bring in mind Rydberg states of ordinary atom with large value of n.

The condition that the dark binding energy is above the thermal energy gives a condition on the value of $h_{eff}/h = n$ as $n \leq 32$. The size scale of the dark largest allowed dark atom would be about 100 nm, 10 times the thickness of the cell membrane.

2.2.4 How molecules in cells "find" one another and organize into structures?

The title of the popular article "How molecules in cells 'find' one another and organize into structures?" (see `http://tinyurl.com/ydbznknn`) expresses an old problem of biology. Now the group led by Amy S. Gladfelter has made experimental progress in this problem. The work has been published in Science [L26] (see `http://tinyurl.com/ybwyugho`).

It is reported that RNA molecules recognize each other to condense into the same droplet due to the specific 3D shapes that the molecules assume. Molecules with complementary base pairing can find each other and only similar RNAs condense on same droplet. This brings in mind DNA replication, transcription and translation. Furthermore, the same proteins that form liquid droplets in healthy cells, solidify in diseases like neurodegenerative disorders.

Some kind of phase transition is involved with the process but what brings the molecules together remains still a mystery. The TGD based solution of this mystery is one of the first applications of the notion of many-sheeted space-time in biology, and relies on the notion of magnetic flux tubes connecting molecules to form networks.

Consider first the TGD based model about condensed and living matter. As a matter fact, the core of this model applies in all scales. What is new is there are not only particles but also bonds connecting them. In TGD they are flux tubes which can carry dark particles with nonstandard value $h_{eff}/h = n$ of Planck constant. In ER-EPR approach in fashion they would be wormholes connecting distance space-time regions. In this case the problem is instability: wormholes pinch and split. In TGD monopole magnetic flux takes care of the stability topologically.

The flux tube networks occur in all scales but especially important are biological length scales.

1. In chemistry the flux tubes are associated with valence bonds and hydrogen bonds [L15] (see `http://tinyurl.com/ycg94xpl`). In biology genetic code would be realized as dark nuclei formed by sequences of dark protons at magnetic flux tubes. Also RNA, amino-acids, and even tRNA could have dark counterparts of this kind [L7] (see `http://tinyurl.com/jgfjlbe`). Dark variants of biomolecules would serve as templates for their ordinary variants

also at the level of dynamics. Biochemistry would be shadow dynamics dictated to high degree by the dark matter at flux tubes.

2. Dark valence bonds can have quite long length and the outcome is entangled tensor net [L14](see `http://tinyurl.com/y9kwnqfa`). These neuronal nets serve as correlates for cognitive mental images in brain (see `http://tinyurl.com/yczv2o5b`) emotional mental images in body [L25] (see `http://tinyurl.com/ydhxen4g`). Dark photons propagating along flux tubes (more precisely topological light rays parallel to them) would be the fundamental communication mechanism [K14] (see `http://tinyurl.com/ydx9dq6x`). Transmitters and nerve pulses would only change the connectedness properties of these nets.

The topological dynamics of flux tubes has two basic mechanisms (I have discussed this dynamics from the point of view of AI [L12] (see `http://tinyurl.com/y75246rk`).

1. Reconnection of flux tubes serves is the first basic mechanism in the dynamics of flux tube networks and would give among other things rise to neural nets. The connection between neurons would correspond basically to flux tube pair which can split by reconnection. Also two flux tube pairs can reconnect forming Y shaped structures. Flux tube pairs could be quite generally associated with long dark hydrogen bonds scaled up by $h_{eff}/h = n$ from their ordinary lengths. Flux tube pairs would carry besides dark protons also supra phases formed by the lone electron pairs associated quite generally with hydrogen bonding atoms. Also dark ions could appear at flux tubes.

   Biomolecules would have flux loops continually scanning the environment and reconnecting if they meet another flux loop. This however requires that magnetic field strengths are same at the two loops so that a resonance is achieved at level of dark photon communications. This makes possible recognition by cyclotron frequency spectrum serving as signature of the magnetic body of the molecule.

   Water memory [K1] (see `http://tinyurl.com/ycqy837a`) would rely on this recognition mechanism based on cyclotron frequencies and also immune system would use it at basic level (here one cannot avoid saying something about homeopathy although I know that this spoils the day of the skeptic: the same mechanism would be involved also with it). For instance, dark DNA strand accompanying ordinary DNA and dark RNA molecules find each other by this mechanism (see `http://tinyurl.com/yalny39x`). Same applies to other reactions such as replication and translation .

2. Shortening of the flux tubes h_{eff}/h reducing phase transition is second basic mechanism explaining how biomolecules can find each other in dense molecular soup. It is essential that the magnetic fields at flux tubes are nearly the same for the reconnection to form. A more refined model for the shortening involves two steps: reconnection of flux tubes leading to a formation of flux tube pair between molecules and shortening by h_{eff}/h reducing phase transition.

Also ordinary condensed matter phase transitions involve change of the topology of flux tube networks and the model for it allows to put the findings described in the article in TGD perspective.

1. Quite recently I wrote an article [L27] (see `http://tinyurl.com/ydhknc2c`) about a solution of two old problems of hydrothermodynamics: the behavior of liquid-gas system in the critical region not consistent with the predictions of statistical mechanics (known already at times of Maxwell!) and the behavior of water above freezing point and in freezing. Dark flux tubes carrying dark protons and possibly electronic Cooper pairs made from so called lone electron pairs characterizing atoms forming hydrogen bonds.

2. The phase transition from gas to liquid occurs when the number of flux tubes per molecule is high enough. At criticality both phases are in mechanical equilibrium - same pressure. Most interestingly, in solidification the large h_{eff} flux tubes transform to ordinary ones and liberate energy: this explains anomalously high latent heats of water and ammonia. The loss of large h_{eff} flux tubes however reduces "IQ" of the system.

The phase transitions changing the connectedness of the flux tube networks are fundamental in TGD inspired quantum biology.

1. Sol-gel transition would correspond to this kind of biological phase transitions. Protein folding [K18] (see `http://tinyurl.com/y9lqmtea`) - kind of freezing of protein making it biologically inactive - and unfolding would be second basic example of this transition. The freezing would involve formation of flux tube bonds between points of linear protein and assignable to hydrogen bonds. External perturbations induce melting of the proteins and they become biologically active as the value of $h_{eff}/h = n$ characterizing their maximal possible entanglement negentropy content (molecular IQ) increases. External perturbation feeds in energy acting as metabolic energy. I have called this period molecular summer.

2. Solidification of proteins reducing is reported to be associated with diseases such neurodegenerative disorders. In TGD picture this would reduce the molecular IQ since the ability of system to generate negentropy would be reduced when $h_{eff}$for the flux tubes decreases to its ordinary value. What brings molecules together is not understood and TGD provides the explanation as h_{eff} reducing phase transition for flux tube pairs.

The evidence for the hierarchy of Planck constants $h_{eff}/h = n$ labelling dark matter as phases with non-standard value of Planck constant [K19] is accumulating. The latest piece of evidence for the hierarchy of Planck constants comes from the well-known mystery (not to me until now!) related to rare Earth metals. Some valence electrons of these atoms mystically "disappear" when the atom is heated. This transition is known as Lifshitz transition. The popular article "*Where did those electrons go? Decades-old mystery solved*" (see`http://tinyurl.com/ychzjg8d`) claims that the mystery of disappearing valence electrons is finally resolved. The popular article is inspired by the article "*Lifshitz transition from valence fluctuations in YbAl3*" by Chatterjee et al published in Nature Communications [L18] (see `http://tinyurl.com/ybejzq87`).

The finding [D3] (see `http://tinyurl.com/ybntawq4`) about misbehaving Ruthenium atoms supports the view that covalent bonds involve dark valence electrons. Pairs of Ru atoms were expected to transform to Ru dimers in thermodynamical equilibrium but this did not happen. This suggests that valence electrons associated with the valence bond of Ru dimers are dark in TGD sense and the valence bonded Ru dimer has a higher energy than a pair of free Ru atoms. The alternative option is that darkness makes the decay of Ru pairs to Ru dimers with smaller energy very slow.

2.2.5 Are mysteriously disappearing electrons dark in TGD sense?

The mysterious disappearance of valence electrons brings in mind dark atoms with Planck constant $h_{eff} = n \times h$. Dark matter corresponds in TGD Universe to a hierarchy with levels labelled by the value of h_{eff}. One prediction is that the binding energy of dark atom is proportional to $1/h_{eff}^2$ and thus behaves like $1/n^2$ and decreases with n.

$n = 1$ is the first guess for ordinary atoms but just a guess. The claim of Randell Mills is that hydrogen has exotic ground states with larger binding energy. A closer examination suggests $n = n_0 = 6$ for ordinary states of atoms. The exotic states would have $n < 6$ and therefore higher binding energy scale [L9, L16] (see `http://tinyurl.com/goruuzm` and `http://tinyurl.com/y7sc98lz`).

This leads to a model of biocatalysis in which reacting molecules contain dark hydrogen atoms with non-standard value of n larger than usual so that their binding energy is lower. When dark atom or electron becomes ordinary binding energy is liberated and can kick molecules over the potential wall otherwise preventing the reaction to occur. After that the energy is returned and the atom becomes dark again. Dark atoms would be catalytic switches. Metabolic energy feed would take care of creating the dark states. In fact, $h_{eff}/h = n$ serves as a kind of intelligence quotient for a system in TGD inspired theory of consciousness.

Could the heating of the rare earth atoms transform some valence electrons to dark electrons with $h_{eff}/h = n$ larger than for ordinary atom? The natural guess is that thermal energy kicks the valence electron to a dark orbital with a smaller binding energy? The prediction is that there should be critical temperatures behaving like $T_{cr} = T_0(1-n_0^2/n^2)$. Also transitions between different dark

states are possible. These transitions might be also induced by irradiating the atom with photons with the transition energy between different dark states having same quantum numbers.

This picture leads to a new formulation of valence bond theory. The lengths of molecular bonds vary in rather narrow range whereas Schrödinger equation suggests that the bond lengths r should scale as $r \propto m^2/Z^2$ for $n = 1$ (m labels the rows of the periodic table). Closed shell electrons screen Z to $Z_{eff} = n_V$, n_V the number of valence electrons so that the formula $e = n^2m^2/Z^2_{eff}$ is a more natural starting point, and conforms with the basic idea about periodic system. This leads to a model allowing to estimate the value of n for given bond allowing also qualitative picture about electro-negativities of valence bonds. Also a comparison with bio-chemistry becomes possible. Hydrogen bond can be understood in terms of de-localization of proton.

2.2.6 About possible implications

The proposed explanation of the disappearing valence electrons allows to sharpen the hypothesis for dark ions. Actually dark atoms with some dark valence electrons would be in question.

1. ORMEs as one manner to end up with $h_{eff}/h = n$ hypothesis

I ended up to the discovery of dark matter hierarchy and eventually to adelic physics [L19], where $h_{eff}/h = n$ has number theoretic interpretation along several roads starting from anomalous findings. One of these roads began from the claim about the existence of strange form of matter by David Hudson. Hudson associated with these strange materials several names: White Gold, monoatomic elements, and ORMEs (orbitally re-arranged metallic elements). Any colleague without suicidical tendencies would of course refuse to touch anything like White Gold even with a 10 meter long pole but I had nothing to lose anymore.

My question was how to explain these elements if they are actually real [K2, K20]. If all valence electrons of this kind of element are dark these element have effectively full electron shells as far as ordinary electrons are considered and behave like noble gases with charge in short scales and do not form molecules. Therefore "monoatomic element" is justified. Of course, only the electrons in the outermost shell could be dark and in this case the element would behave chemically and also look like an atom with smaller atomic number Z. So called Rydberg atoms for which valence electrons are believed to reside at very large orbitals could be actually dark atoms in the proposed sense.

Obviously also ORME is an appropriate term since some valence electrons have re-arranged orbitally. White Gold would be Gold but with dark valence electron. The electron configuration of Gold is $[Xe]4f^{14}5d^{10}6s^1$. There is single unpaired electron with principal quantum number $m = 6$ and this would be dark for White Gold and chemically like Platinum (Pt), which indeed has white color.

2. Biologically important ions as analogs of ORMEs?

In TGD inspired biology the biologically important atoms H^+, Li^+, Na^+, K^+, Ca^{++}, Mg^{++} are assumed to be dark in the proposed sense. But I have not specified darkness in precise sense. Could these ions have dark valence electrons with scaled up Compton length and forming macroscopic quantum phases. For instance, Cooper pairs could become possible and make possible high Tc superconductivity with members of Cooper pair at parallel flux tubes. The earlier proposal that dark hydrogen atoms make possible biocatalysis becomes more detailed: at higher evolutionary levels also the heavier dark atoms behaving like noble gases would become important in biocatalysis. Interestingly, Rydberg atoms have been proposed to be important for biology and they could be actually dark atoms [L6].

To sum up, if TGD view is correct, an entire spectroscopy of dark atoms and partially dark molecules is waiting to be discovered and irradiation by light with energies corresponding to excitation energies of dark states could be the manner to generate dark atomic matter. Huge progress in quantum biology could also take place. But are colleagues mature enough to check whether the TGD view is correct?

2.2.7 Misbehaving Ruthenium atoms

In Facebook I received a link to a highly interesting article (see `http://tinyurl.com/ybntawq4`) with title "*Breakthrough could launch organic electronics beyond cell phone screens*" tailored to catch the attention of techno-oriented leader. My attention was however caught for different reasons. The proposed technology would rely on the observation that Ruthenium atoms do not behave as they are expected to behave.

Ru atoms appear as dimers of two Ru atoms in the system considered. Free Ru atoms with one valence electron are however needed: they would become ions by giving up their valence electrons, and these electrons would serve as current carriers making the organic material in question semiconductor. Irradiation by UV light was found to split Ruthenium dimers to single Ru atoms. If the total energy of Ru dimer is smaller than that for two Ru atoms, thermodynamics predicts that the Ru atoms recombine to dimers after the irradiation ceases. The did not however happen!

Can one understand the mystery in TGD framework?

1. Ru atoms have one outer s-electron at 5:th shell. One would expect that Ru dimer has valence bond with shared 5s electrons. I recently learned about mysteriously disappearing valence electrons of rare Earth metals caused by heating [L18]) (see `http://tinyurl.com/y7cxs8uz`). This gives strong support for the idea that valence electrons of free atoms can become dark in TGD sense: that is their Planck constant increases and the orbitals become large. The analogy with Rydberg atoms is obvious and it could be that Rydberg atoms in some case have dark valence electrons. Since electron's binding energy scale scales like $1/h_{eff}^2$ $h_{eff}/h = n \times h$, the creation of these states requires energy and therefore heating is required. Also irradiation by photons with energy equal to energy difference between ordinary and dark states should give rise to the same phenomenon. This would provide a manner to create dark electrons and a new technology.

2. This also inspired the proposal that valence bond (thought to be understood in chemistry with inspiration coming from the reductionistic dogma) involves flux tube pair and $h_{eff}/h = n$ which is larger than for ordinary quantum theory. This provides new very concrete support for the view that thetransitions from atomic physics to chemistry and from chemistry to organic chemistry could involve new physics provided by TGD [L20] (see `http://tinyurl.com/yaq3459e`).

   The step from atomic physics to chemistry with valence bond would involve new physics: the delocalization of valence electrons to flux tubes due to the increase of h_{eff}! Valence electrons would be dark matter in TGD sense! The step from chemistry to organic chemistry would involve delocalization of proton as dark proton by similar mechanism and give rise to hydrogen bond and also many other new phenomena.

3. The increase of h_{eff} would reduce the binding energy from the expected. This would be the case for so called (and somewhat mysterious) high energy phosphate bond. This picture conforms with the fact that biological energy storage indeed relies on valence bonds.

   If this vision is correct, the breaking of valence bond would split the flux tube pair between two Ru atoms by reconnection to flux loops associated with Ru atom. The resulting pair of free Ru atoms would have lower energy than Ru dimer and would be favored by thermodynamics. The paradox would disappear.

A couple of critical questions are in order.

1. Why irradiation would be needed at all? Irradiation would kick the dimer system over a potential wall separating it from a state two free Ru atoms. Also the magnetic energy of the flux tube would contribute to the energy of dimer and make it higher than that of free state.

2. Why Ru dimers would not decay spontanously to pairs of free Ru atoms? This is the case if the energy needed to overcome the potential wall is higher than thermal energy at temperatures considered. One could also argue that electronic states with different values of $h_{eff}/h = n$ are not in thermal equilibrium: one has far-from-equilibrium thermodynamical state. These electrons would represent dark matter in TGD sense and interact rather weakly with ordinary matter so that it would take time for thermal equilibrium to establish itself.

TGD indeed leads to the proposal that the formation of states regarded as far-from-thermal equilibrium states in standard physics approach means formation of flux tubes networks with $h_{eff}/h = n$ larger than for the original state [L17] (see `http://tinyurl.com/yamdwop9` and `http://tinyurl.com/y8f95b5z`). If this interpretation is correct, then one can also consider the possibility that the energy of the free state is higher than that of the dimer as assumed by the experimenters.

2.3 Does valence bond theory relate to the hierarchy of Planck constants?

The idea that valence bonds, or at least some of them, correspond to non-standard value of $h_{eff}/h = n$ [L17] is very attractive. It could allow to understand what chemical bonds really are and allow a detailed view about how reductionism fails in the sequence of transitions from atomic physics to molecular physics to chemistry to biochemistry.

1. The standard value of n, call it n_{min} need not correspond to $n_{min} = 1$ and the findings of Randell Mills [D4] [L9] suggesting that hydrogen atom and possibly also other atoms can have binding energies coming as k^2 multiples of ordinary ones with $k = 2, 3, 6$, suggests that $n_{min} = 6$ could correspond to the standard value of h_{eff} for atoms. $n > n_{min}$ would mean reduced binding energy and this would mean the possibility of high energy valence bonds.

2. The binding energy of atom would scale as $1/n^2$ so that for non-standard values of $n > n_{min}$ would correspond to smaller binding energy scale. The finding that heating of rare-earth atoms leads to a disappearance of some valence electrons [L18] suggests that the value of n for some valence electrons increases from n_{min} in these situation. The same effect might be achieved by irradiation at suitable photon energies corresponding to energy difference between ordinary state and dark state of electrons. An entire spectroscopy of atoms with dark valence electrons would be waiting to be discovered.

3. $n > n_{min}$ would explain why valence bonds are carriers of metabolic energy liberated in catabolic part of metabolism. The temporary reduction of of n would induce a temporary localication by shortening of flux tubes and in turn make possible bio-catalysis by kicking the reactants over the potential wall making the reaction slow. The shortening of long flux tube bonds between reacts as the value of n is reduced could explain why bio-molecules are able to find each other in the molecular crowd.

4. The Bohr radii of valence electrons of atoms scale as $a_B \propto m^2/Z_{eff}^2$, where m (usually denoted by n) is the principal quantum number determining the value of energy in the model based on Schrödinger equation. Z_{eff} is in good approximation equal to the unscreened nuclear charge $Z_{eff} = n_V$ equal to the number of valence electrons. If the superposition of atomic orbitals restricted to valence bonds is the essence in the formation of molecules, one an argue that the lengths of bonds and radii of molecules should decrease rapidly with Z_{eff}. However, the empirical fact is that the bond lengths vary in a rather narrow range, roughly by factor 2!

The solution of the problem looks rather unique.

1. The value of n assignable to the valence bond is scaled so that nm/Z_{eff} is near to unity so that the Bohr radius is near to that for hydrogen atom. Z_{eff} is naturally the charge unscreened by the closed electron shells and equal to the number $Z_{eff} = n_V$ of valence electrons. This conforms with the periodicity of the periodic table. Since the value of n is same for both bonded atoms, the value of Bohr radii differ which implies that electronic charge is shifted towards the atom with larger n_V and electro-negativities of atoms parameterizing this behavior are different for the atoms of the bond. This conforms qualitatively with the valence bond theory.

   For $n > n_{min}$ one would have $a_B \propto (n^2/n_{min})^2 m^2/Z_{eff}^2$, and if $nm/(n_{min}Z_{eff})$ is constant in reasonable approximation, the estimate for bond length does not depend much on Z. Could the weak variation of bond lengths be a direct indication that the reduction of

molecular physics to atomic physics fails? Also the size of atoms in lattice about $2a_B(H)$ (one Angström) depends only weakly on Z_{eff}: could the constancy of $nm/(n_{min}Z_{eff})$ be true in reasonable approximation also for lattice bonds?

2. The predicted lengths of valence bonds should be realistic: this forces $n > n_H$ and $n \propto Z_{eff}$ is a rough guess. One should also understand the values of electro-negativities $\chi(X)$ allowing quantitative understanding about the distribution of charge along the bond. The bond lengths assignable to the bonded atoms are in general different and the one one with shorter bond length for electrons is expected to be more electronegative since the electrons for it are less de-localized.

2.3.1 Transition from atomic physics to molecular physics and chemistry

The transitions from atomic physics to chemistry and from chemistry to organic and bio-chemistries are poorly understood and the reductionistic dogma remain a mere belief. Could the valence bonds associated with magnetic flux tubes in TGD Universe and correspond to a non-standard value of n scaling up the value of Bohr radius by n^2? Could valence electron pairs form analogs of Cooper pairs with the length of bond defining the size scale of the Cooper pair. This could happen in aromatic cycles playing crucial role in molecular biology. Could various high energy valence bonds making possible the storage of metabolic energy correspond to valence bonds with $n > n_{min}$ possessing therefore smaller binding energy.

One has several options.

1. U-shaped flux tube are along single space-time sheet. U-shape would minimize magnetic energy.

2. One could have closed flux tube going along first space-time sheet A, going to second sheet B through extremely short wormhole contact of size of order CP_2 radius, and returning back along B and back to A through wormhole contact. One would have a pair of flux tubes with opposite values of magnetic fields on top of each other in CP_2 direction. The net magnetic field experienced by a charged particle at QFT limit would vanish: I have called this structure wormhole magnetic field. For wormhole magnetic field the average magnetic field determining the magnetic field at QFT-GRT limit of TGD would vanish in good approximation.

3. One could have single flux tube at sheet A going to B through wormhole contact and returning back along different route along B and returning back through wormhole contact. For a network of flux tubes one could have closed magnetic paths. In this case, charged particles would experience the magnetic field of only single flux tube. This option looks very attractive and one could realize Cooper pairs having members at different space-time sheets. The flux could be also monopole flux possible in TGD Universe thanks to the homology of CP_2.

First and third option look natural in the chemistry of valence bond. The prediction would be that valence electrons are de-localized along these bonds. If the wave function behaves like hydrogen atom wave function it decays exponentially with distance from each atom and a superposition of orbitals would be in question. The Bohr radius would be proportional to n^2 implying longer de-localization scale.

For hydrogen bonds proton would be de-localized as dark proton. This could represent transition from inorganic chemistry to organic chemistry. In TGD inspired quantum biology also other ions can be de-localized at magnetic flux tubes and these de-localizations represent a further steps away from atomic physics.

In biology n would serve as a kind of IQ for a system: understanding why this should be the case requires adelic physics serving as fusion of ordinary physics and physics of cognition represented by p-adic physics [K17] [L19]. The larger the value of n, the larger the maximal value of p-adic counterpart of entanglement negentropy, which is an analog of Shannon entropy but with algebraic number valued probability P appearing in $log(P)$ replaced by its p-adic norm $|P|_p$ for a suitable algebraic extension of rationals. This entropy can be negative and has in this case interpretation as information. The sum of real and p-adic entropies tends to be negative and has interpretation as a measure for conscious information.

2.3.2 Valence bond theory very briefly

How to test this hypothesis about valence bonds? Electronegativity and oxidation/reduction serve as the basic notions in valence bond theory (see `http://tinyurl.com/y8wyd9zm`). Valence rule tells which bonds are favored. Bond lengths and electro-negativities are basic parameters characterizing bonds. Can one interpret these notions in terms of $n = h_{eff}/h$ hierarchy of dark matters?

1. For atom, call it A, bonded to atoms B, C,.. the sum of valences of B, C,.. is the negative of the valence of A. For H-Cl and Na-Cl the valences are +1 and -1. C as valence 4 (or equivalently -4) and CH_4 represents example of this compensation. For O_2= O=O one as double valence bond.

2. Bond length is the first key parameter allowing to get idea about valence bond. The table of Wikipedia article about the notion of bond length gives the bond lengths of C with other elements (see `http://tinyurl.com/ya4md73c`). Interestingly, C-H, C-C, C-O, C-N, C-S, C-Se bond lengths vary, which might have interpretation in terms of varying value of n: all bonds are important in biology. An alternative explanation for the variation would be that there are also other atoms involved.

   The range of variation is [106, 112] pm for C-H; [120, 154] pm for C-C (the upper limit is achieved for diamond but even longer bond lengths are known), [147, 270] pm for C-N , [143, 215] pm for C-O (note that bond length for C-O-H is thus longer than for C-H), and [181, 255] pm for C-S.

   Average bond lengths tend to decrease along the row of the periodic table and increase along column. The C-X bonds in hydrocarbons (alkenes, alkynes) are shorter than in organic polymers in general, which supports the view that they have as organic but non-living materia lower value of n than organic compounds in living matter. The bond lengths for C-metal bonds are rather long, for instance for C-Mg bond length is 207 pm, roughly twice C-H bond length.

3. Electronegativity χ is second key parameter and allows a quantitative description of valence bonds. The rule is that the electrons of an atom with smaller electronegativity χ , call it A, tend to be nearer to those of the atom B with higher value of χ: one says that B oxidizes A and B is reduced. Both oxidation and reduction occur always and one talks about redox reactions, which are fundamental in biology. The term oxidation follows from the fact that oxygen O_2 is the best known oxidant.

   The values of electronegativity for various elements are listed in Wikipedia article (see `http://tinyurl.com/pbh6r6c`) and give a rough idea about what happens for the valence electrons in various bonds. The reduction to two-atom level is only an approximation since the presence of other atoms modifies χ. For instance, the electro-negativities of C for C=O and C-(O-H) are different.

   For instance, one has $\chi(X) \in \{2.20, .98, .93, 1.00\}$ for $X \in \{H, Li, Na, Ca\}$ with $(m, Z) \in \{(1, 1), (2, 7), (3, 11), (4, 20)\}$. Clearly, one has $\chi(H) \sim 2\chi(X)$.

   A naïve expectation is that the atom with the smaller value of n/Z is more electronegative (note that valence rule must be satisfied). Indeed, electronegativity increases along the row of the periodic table. Electronegativity decreases slowly along the column of periodic table except for the metals in the columns containing Cr, Mn, Fe, Co, Ni, Cu, Zn at top row. Understanding the explicit dependence between $\chi(X)$ and $a_B(x)$ and other parameters involved would require a more detailed model.

2.3.3 Deducing an estimate for the value of $n = h_{eff}/h$ from bond lengths

Valence bond lengths provide information allowing to estimate the value of $n = h_{eff}/h$.

1. The expectation is that the bond length for bond A-B scales as the minimum of Bohr radius for the two atoms that is minimum value of $a_B \propto n^2 m^2/Z^2$ for atoms A and B. Here one has $n = h_{eff}/h$, m (usually n) denotes the principal quantum number of valence electron, and Z the charge of the atomic nucleus. The atom with smaller value of m/Z should dictate the bond length.

2. If bond length assumed to be of order Bohr radius as function of (Z_{eff}, m), its reduction as function of m/Z_{eff} is quite too slow to be consistent with m^2/Z_{eff}^2 behavior expected for ordinary Planck constant (see the table of `http://tinyurl.com/pbh6r6c`). The formula $a_B \propto n^2m^2/Z_{eff^2}^2$ and the increase of n as function of Z_{eff} compensating the reduction of a_B due to the increase of Z_{eff} for valence bonds is suggestive.

   The first guess is that the formula $a_B(nZ_{eff}/m) = a_H$ holds true apart from factor of order 2. This would explain why valence bond lengths vary in so narrow length scale range. This fact could be even seen as argument against the reduction of chemistry to atomic physics.

The model is based on the following arguments.

1. The value of n is same for both atoms at the ends of the bond. Since the Bohr radius of atom with smaller value of nm/Z_{eff} gives rise to a smaller de-localization length of orbitals, the value of n for heavier atom, call it X, determines the length of flux tube which should be of order $2 \times a(X)$. Since the Bohr radius of the atoms with larger value of nm/Z_{eff} is longer, the electrons of this atom are more de-localized and tend to be nearer to atom with the smaller value of nm/Z_{eff}. The higher the value of Z with same value of m for both atoms the higher the electronegativity. This conforms with empirical facts.

2. The electronegativity of H is roughly twice the electronegativity of the alkali-atoms in the above example. The naïve application of the above argument this would suggest that nm/Z_{eff} for alkali atoms must be larger than n so that de-localization of electron of alkali atom would make hydrogen atom more electronegative. This of course cannot be the case. The solution of the problem is that one cannot apply the rule without taking into account valence rule. For C, N, O, F and S, Cl the electro-negativities are higher than for H. Note that one has $\chi(P) = 2.19 \sim \chi(H) = 2.20$. Interestingly, P occurs with valence 5 in phosphate.

3. $n(H) = 6$ suggested by the findings of Mills [D4] [L9] and will be assumed.

With these assumptions, one can consider two options fixing the value of $n(X)$ using as a guideline empirical data about bond lengths telling that they vary in rather narrow rang $[2, 6]a_H$.

1. For Option I one would have $a(X) = a_B(H)$ implying that all Bohr radii and bond lengths are same and equal to those for hydrogen. Bond length would be in good approximation twice the hydrogen atom Bohr radius: $r = 2a_H$. This condition is satisfied approximately for quite a number of bond lengths. The radii however vary roughly in the range $[1, 3] \times 2a_H$.

   Option I would give

$$n^2(X) = (\frac{Z_{eff}}{m})^2 n^2(H) \quad .$$

   For given row characterized by the value of m one would have

$$n(Z, m) = \frac{Z_{eff} n_H}{m} = \frac{6Z_{eff}}{m} \quad .$$

2. $n_H = 6$ proportionality for n allows besides $n = Z_{eff} n_H/m$ also more general option: call it Option II. One can have

$$n(X, \frac{k}{l}) = \frac{l}{k} \times n(Z_{eff}, m) = \frac{l}{k} \times \frac{6Z_{eff}}{m} \quad ,$$

   where $k \in \{2, 3, 6\}$ is non-trivial divisor of $n_H = 6$ besides. This scales the Bohr radius $a(mn/Z_{eff}) = a_H$ to

$$a(mn/Z_{eff}) = (l/k)^2 a_H \quad .$$

For instance, $l/k = 3/2$ would give Bohr radius $a(X) = 9a_H/4$ somewhat above $2a_H$. $l/k = 4/3$ would give Bohr radius $16a_H/9$ and $l/k = 5/3$ would give Bohr radius $a(X) = 25a_H/9$ slightly below $2a_H$. The largest bond lengths are about $6a_H$. These two mechanisms could explain the variation of the bond length. This option would explain the bond lengths which $1-3$ times the minimal bond length $r = 2a_H$.

3. The value of the Bohr radius is not affected much if $n(Z_{eff}, m)$ is replaced with the nearest integer. This because for large enough n one the relative change $\Delta r/r = \Delta a_B/a_B$ satisfies $\Delta r/r \simeq 2\Delta n/n = (2m/Z_{eff}n_H)\Delta n = (m/3Z_{eff})\Delta n$. This allows fine tuning of the bond length for both options.

Consider now different rows of the periodic table for Option I. The lengths for Option II can be deduced from this option by scaling by $(k/l)^2$, $l = 2, 3, 6$.

1. $m = 2$: For $X \in \{Li, Be, B, C, N, O, F\}$ with $Z_{eff} \in \{1, ..., 7\}$ and $m = 2$ one $n(Z_{eff}, m) = 3Z_{eff} \in \{3, 6, ..., 18, 21, \}$. The highest values of n are in this row and this might be of biological significance. Indeed, large n means large metabolic energy and C,N, and O are fundamental in metabolism.

2. $m = 3$: For $X \in \{Na, Mg, Al, Si, P, S, Cl\}$ one has $m = 3$, $Z_{eff} \in \{1, .., 7\}$. One $n(Z_{eff}, m) = 2Z_{eff}$ $n(X) \in \{2, 4, ..., 14\}$. The common values of n are in $n = 6$ corresponding to Be and Al and to $n = 12$ corresponding to C and S: note that also S corresponds to large metabolic energy. Note that P and S with $n = 12, 14$ are also important in metabolism. Whereas the lighter atoms serve control purposes.

3. $m = 4$: $X \in \{K, Ca, Sc\}$ have $Z_{eff} \in \{1, 2, 3\}$, metals $\{Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn\}$ have $Z_{eff} \in \{4, ..., 12\}$ and $\{Ga, Ge, As, Se, Br\}$ have $Z_{eff} \in \{13, ..., 17\}$ have $m = 4$. One has $n(Z_{eff}, m) = 3Z_{eff}/2$ having also half odd-integer values. This gives $\{1, 3/2, 2\}$ for $X \in \{K, Ca, Sc\}$ and $\{5/2, ..., 17/2\}$ for $\{Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn\}$ and $\{9, ..., 11\}$ for $\{Ga, Ge, As, Se, Br\}$. The total variation range for n is $[1/2, 11]$.

   Alkali atoms K, Ca and metals Mn, Fe, Co, Ni, Cu, Zn are biologically important. The corresponding metabolic energies are however not so large as for lower rows and this ions indeed seem to serve for control purposes. (Li,Be,B) and (V,Cu,Ga) have same values of n as also (Na,Mg,Al,Si,P) and (Sc,Mn,Co,Cu,As). Interestingly As is reported to play the role of P in some exotic metabolism.

   One could understand the deviations of bond length from the ideal value by allowing small variations of $n(Z_{eff}, m)$. In particular, the replacement of half-odd integer with integer would not considerably affect the bond length.

4. $m = 5$: For $m = 5$ the values of $n(Z_{eff}, m)$ are not integers for the proposed model unless Z_{eff} is divisible by 5. One has $Z_{eff} \in \{1, ..18\}$. The maximum integer value of n is 3. This allows only Nb, Pd,Sb. Could this relate to the fact that heavier atoms are not so important biologically? The atoms near these 3 atoms

5. $m = 6$: For $n_H = 6$ one has $n(Z_{eff}, m) = Z$ for $m = 6$ atoms. Could integer valuedness mean that these atoms might be somehow special?

6. The scale of variation of n degreases with m and this suggests smaller scale of variation for both valence bond length and electron-negativity. The range for the variation of latter indeed decreases along the columns of the periodic table. Also the values of n decrease along the colum of the periodic table: also this conforms with the empirical facts.

To sum up, it seems that one can understand bond lengths quite satisfactory and deduce from the values of n if the proposed model is accepted. The most important outcome would be explanation for the fact that bond lengths do not scale like $(m/Z_{eff})^2$ as standard quantum theory would suggest.

2.3.4 About biological interpretation

$h_{eff}/n = n$ for valence bond serves as a kind of IQ and also for the metabolic energy carried by molecule in valence bonds. This suggests that biologically important molecules should have larger value n. One can test this hypothesis.

1. Difference in χ means that valence electrons are shifted toward the more electro-negative atom of the valence bond. As found, the larger value of $a_B(nm/Z_{eff})$) for the atom with smaller value of nm/Z_{eff} allows to understand why it is more electronegative.

2. By the above proposal large value of mn/Z_{eff} corresponds to long valence bond and therefore de-localization of valence electron to long scales. The length of valence bond presumably depends also on other parameters. In any case, bond length could be taken as a rough indication about the value of n associated with the bond and the above estimate for n can serve as a starting point. The variation of bond length might allow interpretation in terms of variation of n.

3. The shortest bond lengths would correspond to smallest value of n possibly assignable to what is identified as waste in metabolic reactions. Small value of n also means large binding energy so that the waste molecules in cellular respiration should have short valence bonds. High energy phosphate bond (...P-O-P...) between two phosphates - say in ADP and ATP - would correspond to a large value of n and the bond should be long. Note that P behaves as valence 5 element in phosphate.

Consider the possible implications in more detail.

1. $h_{eff}/n = n$ for valence bond serves as a kind of IQ and also for the metabolic energy carried by molecule in valence bonds. This suggests that biologically important molecules should have larger value n. One can test this hypothesis.

   (a) Difference in χ means that valence electrons are shifted toward the more electro-negative atom of the valence bond. As found, the larger value of $a_B(nm/Z_{eff})$) for the atom with smaller value of nm/Z_{eff} allows to understand why it is more electronegative.

   (b) By the above proposal large value of mn/Z_{eff} corresponds to long valence bond and therefore de-localization of valence electron to long scales. The length of valence bond presumably depends also on other parameters. In any case, bond length could be taken as a rough indication about the value of n associated with the bond and the above estimate for n can serve as a starting point. The variation of bond length might allow interpretation in terms of variation of n.

   (c) The shortest bond lengths would correspond to smallest value of n possibly assignable to what is identified as waste in metabolic reactions. Small value of n also means large binding energy so that the waste molecules in cellular respiration should have short valence bonds. High energy phosphate bond (...P-O-P...) between two phosphates - say in ADP and ATP - would correspond to a large value of n and the bond should be long. Note that P behaves as valence 5 element in phosphate.

   (d) C and Si atoms are expected to form linear polymer-like structures with long valence bonds and large and varying value of n proportional to $Z_{eff} \simeq n_V$, n_V the number of valence electrons and guaranteeing that the bond length has correct value varying in rather narrow range. Of course, bonding of atoms with additional atoms as occurs in multi-phosphates could allow also linear structures. This could partially explain why life is Carbon based.

   The proposed valence theory allows a view about the role of C. The length of C-H bond is determined by $n(C)$ with larger $n_V(= 4)$ so that the valence electron tends to be nearer to C: $\chi(C) = 2.55 \geq \chi(H) = 2.2$ conforms with this. $n(C-H) = n(C-C)$ predicted. The high negentropy of C-H bond could explain why also C-H bonds are so typical in biology. Note that petroleum consists of carbohydrates and liberates energy, supporting the view that non-standard value of n is associated with the valence bonds also in this case.

Graphite is obtained by putting 2-D graphene layers on each other. In graphite C has valence bonds to 4 C:s and in graphene to 3 C:s. An interesting question is whether this might relate to some very special properties of graphene and whether it might correspond to larger than usual value of n. Not that these structures, in particular graphite, are much less dynamical than polymers.

(e) Si is second candidate for the basic atom of life. The values of n for C-H bonds and C-C bonds are in good approximation proportional to n_V/m and in ratio $n(m = 2, Z_{eff})/n(m = 3, Z_{eff}) \simeq 3/2$. $n(C) > n(Si)$ implies that C-H and C-C bonds are more negentropic and energetic favoring Carbon based life. Also the C-N and C-O bonds are more negentropic and energetic than Si-P and Si-S bonds.

Note also that $\chi(Si) = 1.9$ is smaller $\chi(H) = 2.20$ so that the electron is nearer to H making it effectively negatively charged. Silanes (hydrosilicons) are very reactive. Also this could relate to the fact that Si based life is not realized.

1. Redox reaction and energy metabolism

Oxidation means the transfer of electrons towards more electronegative atom - not necessary oxygen - and means shorter de-localization scale for electrons and shorter bond unless the value of n increases.

(a) Oxidation happens when nutrients are catabolized so that they give the metabolic energy stored into the valence bonds, which could be rather stable due to the non-standard value of n. This rule would hold true quite generally. Bio-catalysis would temporarily reduce the value of n for various bonds and liberate energy allowing to kick the reacting molecules over the potential wall preventing the reaction.

(b) Aerobic cell respiration relies on oxygen. At the bottom of the catabolic cascade is glucose C_6H_{12} O_6 decomposed into CO_2 =O=C=O and water. The liberated energy is used to transform ADP to ATP. C=O group acts as the functional group because C is effectively slightly positively charged and attracts negative ions and negative parts of molecules so that it is highly reactive. C=O bond length is 116 pm and considerably shorter than C-O bond length (in say C-O-H) (about 143 pm in paraffin, see `http://tinyurl.com/y95bkooa`). This conforms with the assumption that n is smallest in CO_2 so that in this sense it would be waste.

Note however that the value of n is higher than $n = n_H = 6$ (taking seriously the findings of Mills [D4] [L9] also for O in CO_2. This should relate to the special role of CO_2 and $H_2(O)$ concerning life. In fact, in both cases the value of $n(O)$ for bonds involved is almost maximal possible in the entire periodic table. Only F has larger n but is too reactive. Hence O is optimal choice both negentropically and energetically. S is second candidate for the role of O but $n(S)$ is by factor 2/3 smaller. Hence $m = 2$ row of the periodic table is optimal for life.

Remark: A rough estimate of the proposed valence bond theory for the ratio of the values of n for C-C and C-O bonds assuming that all bonds have the same length would be $n_V(O)/n_V(C) = 3/2$.

(c) The waste products of metabolism should consist of compounds, which do not have C-C bonds, in particular molecules having only single C atom. The flux tubes associated with the valence bonds should have low value of n and correspond to low molecular IQ. Bond lengths and de-localization lengths should be short. The molecules should involve typically single carbon atom or no carbon atoms.

Carbon di-oxide CO_2 with valence structure O=C=O represents basic example about outcome of oxidation. CO_2 is the basic organic waste product of metabolism and indeed has especially short bond length. C=O group is functional since oxidation makes C slightly positively charged so that it attracts negative ions and negatively charged parts of molecules. Also ammonium NH_3 is waste product and now electrons are shifted towards N as one finds by comparing the electronegative of H and N appearing in the table of Wikipedia article (see `http://tinyurl.com/pbh6r6c`). As already noticed, the notion of "waste" is only relative notion.

Urea (H_2-N)-C(=O)-(N-H_2) is second waste product. As a matter of fact, liver forms urea and water by combing CO_2 with two NH_3 (ammonium) molecules. Liver puts two waste molecules to single packet.

(d) Also H_2O has high negentropy and energy contents although it appears as "waste" in cell respiration. The presence of hydrogen bonds between water molecules gives rise to dark protons, which also affects the situation. Photosynthesis indeed has water and CO_2 input elements so that it makes sense for them to have high negentropy and energy content.

Remark: Solar light would generate negatively charged exclusion zones of Pollack [L2] [L2] crucial for life.

One can look the situation also from the view point of storage of metabolic energy and negentropy.

(a) Hydroxy group O-H (see `http://tinyurl.com/y7uv924k`) attached to C appears in sugars with chemical formula $C_nH_{2n}O_n$. For the simplest hydrocarbons one would have formula C_nH_{2n} apart from boundary corrections at the ends of the polymer. Sugars store more metabolic energy than hydrocarbons and the valence theory should allow to understand this. The rough estimate of the proposed valence bond theory for the ratio of the values of n for C-O and C-H assuming that all bonds have the same length would be $n_V(O)/n_V(C) = 3/2$. This predicts that sugars are more negentropic and energetic than hydrocarbons.

(b) C-O bond length is in the range [143,215] pm and C-H bond in the range [106,112] pm. The value of n for C-O-H bond must be higher than predicted by the assumption that the bonds have equal lengths. The replacement $n(O) \to 3/2n(O)$ allowed by $n_H = 6$ would predict that the ratio of C-H and C-O bond lengths is $9/4$. Smaller variations of $n(O)$ are also possible. This would increase further the negentropy and energy contents of O and conform with Negentropy Maximization Principle (NMP), whose statistical form is a prediction of adelic TGD [L19] [K17].

(c) The Wikipedia article about hydroxy group tells that compounds containing hydroxyl groups (O-H) tend to form hydrogen bonds forcing them to stick together. This would mean formation of dark protons and suggests formation of flux tube networks, which could be also behind the formation of water molecule clusters and be fundamental aspect in the formation of systems with life-like properties [L17] (see `http://tinyurl.com/yassnhzb`). O-H is thus favored over H also for this reason.

(d) One can understand also the somewhat mysterious high energy phosphate bond. Phosphate has chemical formula $(P{=}O)O_3^-$. In phosphate the contents of metabolic energy and negentropy are maximized for the proposed model for valence bonds since only F has higher value of n than O in the periodic table assuming that bond lengths are identical. The actual bond lengths require that the value of $n(O)$ is even higher than this.

2. DNA, RNA, and amino-acids

What about other biomolecules such as DNA and amino-acids?

(a) DNA (see `http://tinyurl.com/cpndtse`) involves the backbone consisting of a sequence of phosphates $(P{=}O)O_3^-$ and ribose molecules. The 6-cycles of ribose molecules contain 5 carbon atoms and one oxygen atom. As already noticed, phosphate has very high energy and negentropy contents. P has very nearly the same electronegativity (2.19) as H (2.20) and O has electronegativity 3.44 so that the P-O bonds resemble H-O bonds as far electronegativity is considered.

The aromatic 5- and 6-cycles of DNA involving de-localized electrons contain two N atoms besides C atoms. The electro-negativities are $\xi(C) = 2.55$ and and $\xi(N) = 3.04$ so that electrons should be nearer to N. The length of C-N bond is longer than C-C bond so that the values of n could be the same and n for C-N bond could be even higher than

for C-C bond so that it would be more negentropic. This could explain why nitrogens are present in DNA rings rather than only carbon atoms. Note that DNA strands are connected by N$\cdots$N and N$\cdots$O hydrogen bonds possibly involving dark protons.

In RNA (see `http://tinyurl.com/cmvyw2r`) one C-H in the ribose is replaced with C-O-H in pentose ring. A, T, C, G are replaced with A, U, C, G (T is methylated form of U obtained by replacing -H with -CH_3). Only short strands of RNA appear and RNA does not have double stranded form but has single stranded form forming double helix. An interesting question is why the replacement of C-H with C-O-H in the pentose inducing change in electronic charge distribution affects so dramatically the properties of DNA. O-H group is functional and involved with the formation of hydrogen bonds. Maybe quantum criticality of ribose has something to do with the widely different properties of DNA and RNA.

(b) Amino-acids (see `http://tinyurl.com/jsphvgt`) have structural formula H_2N- ((C-H)-R)-((C=O)H)-OH, where R is the residue responsible for the functional properties of the amino-acid. Amino-acid polymers have backbone involving N-C bonds formed between amino-group N-H_2 and carboxyl group (C(=O)H)-OH by hydrolysis giving rise to peptide bond ...(C(=O)H)-NH... plus H_2O. Therefore the backbone consists of ...-(C(=O)H))-(NH)-...-(C(=O)H))-(NH)... sequence containing ((C-H)-R) between molecules of the backbone.

Assuming same N-C and C-C bond lengths the proposed valence band theory predicts $n(N) = (n_V(N)/n_V(C)) = 5n(C)/4$ implying that higher content of metabolic energy and negentropy favors C-N bonds instead of C-C bonds. That the catabolism of peptides to sugars liberates metabolic energy conforms with this.

2.3.5 About the biological role of low valence ions

A comment about the role of biologically important ions is in order. As a rule they tend to have low valence, especially those whose cyclotron frequencies for $B_{end} = .2$ Gauss seem to be important biologically. The possibly existing valence bonds between atoms towards the left end of the rows of the periodic table (Li,Na,K,Ca, Mg,..) - if they even exist at all - have low valence and low value n satisfying $n \geq 6$ (note that the valence of the bond is the valence of the atom with higher valence).

(a) The potential negentropy content of low valence bonds is low and also metabolic energy content defined as difference of energy from the situation in which one has $n = 6$ derived from the experiments of Randell Mills [L9]. Thus low valence bonds are not important for metabolism.

(b) Low valence ions have however different role: they appear as biologically important positive ions important for the communications to and control by MB. For instance, dark photons with cyclotron frequencies in magnetic fields of flux tubes would be involved with control by dark photons. These dark photons could also transfer energy to MB. The values of n for dark photons can be as high as $n \sim 10^{12}$ or even higher from the condition that the energies of dark photons with frequencies in EEG range are above thermal energy or even in visible and UV range for bio-photons.

Values of n for dark ions could be thus much higher than for electrons at valence bonds if their cyclotron energies correspond to dark photon energies. Dark photons and dark cyclotron condensates would represent a higher level of evolutionary hierarchy and control and coordination in quite long length scales responsible for the quantum coherence of living matter.

Remark: Recall that the assumption $\hbar_{eff} = \hbar_{gr} = GMm/v_0$, where $v_0 > c$ has dimensions of velocity, m mass of the charged particle, and M some large mass, guarantees universality of cyclotron energy spectrum (spectrum of bio-photons in visible and UV range). This gives $n \sim 10^{13}$ for 10 Hz cyclotron frequency photon energy about 1 eV. Fe^{++} has $f_c = 10$ Hz in $B_{end} = .2$ Gauss.

1. Some examples about biologically important ions

One can consider some examples about biologically important ions.

(a) In TGD protons H^+ appear as dark protons. The small value of the atomic binding energy would explain why hydrogen appears as ion: dark atoms with this value of n would have extremely large size. Dark protons need not of course have the value of n characterizing dark EEG photons. Rather, entire hierarchy of frequency scales is expected ranging down to the energies of IR photons still above the thermal energy.

(b) Hydrogen bond carrying de-localized proton would serve as the simplest example and be associated with magnetic flux tube. Hydrogen bonded water molecule clusters are crucial for life. Hydrogen bonds are also formed between OH groups of say water and some other high valence atoms.

Dark DNA/RNA/amino-acid/tRNA realized as dark proton sequences at magnetic flux tubes and realizing vertebrate genetic code (prediction) would be second realization giving rise to dark nuclei [L7]. Cell membrane as generalized Josephson junction would involve electronic Cooper pairs and dark protons or even their Cooper pairs [K11]. At microscopic level membrane proteins defining various ion channels and pumps would act as generalized Josephson junctions.

(c) What about heavier ions? Their dark variants appear at MB and play a key role in TGD based model for quantum biology and neuroscience. They appear at flux tubes assignable to generalized Josephson junctions and at layers of MB in much longer scales (note that hydrogen bond is analogous to Josephson junction). Dark ions carrying much more information in BE condensates than dark valence electrons would serve control purposes whereas dark electrons at valence bonds would carry metabolic energy.

(d) What about noble gases? Can one say that they have maximal valence or do they have vanishing valence and therefore $n = 6$ as the findings of Mills suggest? If they had maximal valence they should be biologically important but they are not: thus $n = 6$ identification is feasible. Ions at the right end of the rows of periodic table, say Cl^- ion, are like noble gas atoms as far as valence is considered. The electronic negentropy of H-Cl understood as H^+ bonded with Cl^- (ionic bond rather than valence bond) and metabolic energy content would be minimal. Cl^- could however form cyclotron condensates with a large value of n, which would explain its biological importance.

Amusingly, plastic balls in plasma of Ar^+ ions appear in the experiment demonstrating life like properties of this system ("breathing") [L17]. Ar^+ would have maximal possible valence and thus maximal value of n and would appear at flux tubes.

2. How the ionization is possible in living matter?

The appearance of ions in living matter looks mysterious. Same is true concerning ions in electrolytes. It is easy to talk about cold plasma but much more difficult to answer the question how this cold plasma can be created. Usually the formation of plasma involves ionization, which requires high temperature of order of the atomic binding energy for the valence electrons of the atom. For hydrogen atom the binding energy is around 13 eV, which corresponds to a temperature of roughly 130,000 Kelvin! This is three orders of magnitude higher than room temperature! In electrolyte the presence of rather weak electric fields cannot explain why the ionization takes place.

For some reason chemists and biologists do not spend much time in pondering fundamentals and theoreticians enjoying monthly salary have a highly irreverent attitude to these disciplines as an intellectual entertainment of lower life-forms. Therefore also this question has been guided under the rug and stayed there.

TGD based explanation for the paradox is simple. If the value of $h_{eff}/h = n$ for valence electrons is high enough, the binding energy, which is proportional to $1/n^2$, becomes so high that a photon with rather low energy, say infrared (IR) photon, can be ionize the dark atom. One can say that the atoms in this state are quantum critical, a small perturbation can ionize them.

i. In the TGD based model of cold fusion as dark nucleosynthesis the atoms would have $n = 2^{12} = 2056$ and the ionization would create dark nuclei as sequences of dark protons at magnetic flux tubes [L13].

ii. In the TGD based model for the analogs of DNA/RNA/amino-acid sequences/tRNA as dark proton sequences the value of n would be of the order of 10^6 higher so that the distance between dark protons, would be a same as between DNA letters, about 3 Angstroms. For these values of n dark atoms are unstable at room temperatures.

iii. In Pollack effect [L2] the irradiation by IR light or visible light or by pumping energy to the system by some other means produces negatively charged exclusion zones (EZs) in which water molecules form hexagonal layers and obey the effective stoichiometry $H_{3/2}$ O. Part of protons (every fourth) goes to magnetic flux tubes as dark protons. How it is possible to create this state by IR radiation?

   A. The original assumption was that in second OH bond of water molecule is excited to a high energy state near to ionization energy so that IR photon can split the bond. The question is: why and how? Do the UV photons from solar radiation cause the excitation?

   B. A more elegant option is that the value of n for the second O-H bond is so large that the bond binding energy is so small that IR photon can split the bond. Solar UV photons could induce the dark excitation. Taking 5 eV as rough estimate for the bond binding energy in the normal state water, this requires the reduction of energy by a factor of order 10^3 to give IR energy .05 eV (energy scale assignable to the membrane potential eV). n would increase by factor of order $2^5 = 32$ from its value for O-H bond according to standard chemistry. A small push by absorption of IR photon can split the O-H bond and create dark proton at flux tube. Any perturbation feeding to the system this energy can induce the kicking of dark proton to flux tube. The generalization of this mechanism to various atoms could be one of the basic mechanisms of quantum criticality in living matter.

3 Revolution in chemistry

This section was inspired by a link to a very interesting article with title "Rules of attraction: Strange chemical bonds that defy the textbooks" (`https://cutt.ly/Jner49B`) telling of new chemistry. Unfortunately, a subscription to New Scientist was required. It was however easy to find in the web several popular articles telling about the changing views concerning chemical bonds.

The article "This weird chemical bond acts like a mash-up of hydrogen and covalent bonds" (`https://cutt.ly/Snetr52`) tells about hybrids of hydrogen and and covalent bonds. For short bond lengths these bonds become strong valence bonds and for long bond lengths weak hydrogen bonds which can even have length of 3 Angstrom.

The article "Strange bonds entirely new to chemists predicted in ammonia hydrides" (`https://cutt.ly/1netzra`) tells that ammonium NH_3 can form in the presence of hydrogen in very high pressure an exotic compound NH_7, which can decay to NH_4^+ + H_2+ H^-. NH_4^+ is also exotic.

The article "Sticking together: Another look at chemical bonds and bonding" `https://cutt.ly/cnetPvG` discusses the theory of chemical bonds proposed by Prof. David Brown, which has turned out to be very successful.

3.1 Two theoretical views about chemical bonds

In the following the bond theory of David Brown and the TGD view about chemical bonds are discussed and compared.

3.1.1 The bond theory of David Brown

The bond theory of David Brown is published as an article with title "Another look at bonds and bonding"in Structural Chemistry 31(1), 2019 [D1] (`https://cutt.ly/eneociZ`).

i. The theory involves the notion of electric flux as a purely classical element. The delocalization of valence electrons is of course a non-classical element and one can argue that this aspect is not well-understood in standard chemistry. In the TGD framework, the counterpart of electric flux is a flux tube carrying magnetic flux, which can be monopole flux. The tube can also carry an electric flux and a simple modification of purely magnetic flux tubes gives tubes carrying also an electric flux.

ii. The key concept besides the notions of valence defined as the number N_v of valence electrons belonging to bonds, and the number of valence bonds N_b, is valence strength defined as $S_v \equiv N_v/N_b$. The total electric flux is the sum of fluxes assignable to the bonds and equals to the total electric charge -N_ve of valence electrons.

   By flux conservation, the electric fluxes at the ends of a given bond are opposite and this gives a strong constraint on the model. This condition is new from the point of standard bond theory and is purely classical.

iii. The configurations with minimum energy are expected to be symmetric. In this case, the electric fluxes for the bonds are expected to be identical and proportional to the common bond strength.

   A. An important implication of flux conservation in the symmetric case is that the valence strengths must be the same for bonded atoms. This condition excludes a large number of candidates.

   B. If N_b is larger than N_v, the flux is fractional. This would represent an exotic situation. An interesting question is whether the flux could correspond to a quark pair or two quark pairs possible in the TGD framework in long scales. The idea that atoms could involve quarks looks of course rather outlandish from the standard model perspective. In this case the flux would be 1/3:rd or 2/3:rd of the flux associated with a single valence electron.

iv. The model works for many kinds of bonds, and is claimed to work even for hydrogen bonds, and can be used to predict possible bonding structures. What is remarkable, that the notion of conserved electric flux assignable to chemical bonds resonates with the TGD view that non-trivial space-time topology behind the notion of flux tube is directly visible at the level of chemistry.

3.1.2 TGD view about chemical bonds

I remember the time when I realized that TGD suggests a description of the chemical bond in terms of the space-time topology. Could chemistry books be wrong, was the question, which I barely dared to articulate.

Gradually I learned that chemistry books do not really allow any deeper understanding of chemical bonds. One just says that they follow from Schodinger equation but computational complexity prevents proving this.

1The TGD based view about valence bonds

TGD indeed implies a revolution in chemistry. Chemical bonds are accompanied by flux tubes possibly carrying dark particles with effective Planck constant $h_{eff} = h_0 > h = 6h_0$. Valence electrons of the less electronegative atom would get to the flux tube and become dark. This leads to a model of valence bonds [L15] predicting that the value of $h_{eff}/h_0 = n$ increases as one moves to the right along the row of the periodic table. This implies a delocalization of the valence electrons to longer scale scaling like h_{eff}^2 for the Bohr model and this is essential for the delocalization. This delocalization would be essential for chemistry of valence bonds and for biochemistry in particular. In metals delocalization would occur in the scale of lattice.

Also $h_{eff} < h$ bonds are in principle possible. Randell Mills has found evidence for a variant of hydrogen for which energies are scaled by a factor 1/4: this would mean $h_{eff} = h/2$ [D4] [L9].

The strange disappearance of the valence electrons of some transition metals in heating has been also known for decades [D3, L18] [L18]: heating would provide the energy needed to increase h_{eff} for valence electrons so that they become dark relative to us? Note that in TGD based biology metabolic energy would be used to increase h_{eff}, which serves as a kind of universal IQ as a measure of algebraic complexity.

An interesting possibility is that in the past scaled down atoms with $h_{eff} = h/2$ have existed [L34]. Could they correspond to most of the dark matter, the primordial dark matter? In the same article, it is also proposed that the Cambrian explosion involving a dramatic leap in biological evolution involved a phase transition in the Earth's scale doubling the radius of the "atomic" flux tubes with thickness of order atomic scale or order 1 Angstrom.

The presence of the "atomic" flux tubes makes it possible to understand the scale of atoms which depends only weakly on atoms although the Bohr radii of valence electrons are typically considerably smaller than atomic scale. The doubling of the flux tube radius by a factor two would have induced the doubling of the atomic size scale. This would have induced the doubling of h_{eff} for valence electrons. This phase transition would have led to the emergence of biochemistry.

2. Hydrogen bonds in the TGD framework

The popular article (`https://cutt.ly/Jner49B`) also mentions bonds without electrons. These bonds would make possible entanglement between atoms.

Hydrogen bond is an example of non-valence bond. Hydrogen bonds are special in that they can be as long as 3 Angstroms. The theory proposed by Brown would describe hydrogen bonds in terms of electron's delocalization.

In TGD framework it would be a proton that becomes dark delocalized to a flux tube accompanying the hydrogen bond, and has therefore $h_{eff} > h$ [L35]. In water one could have a spectrum of h_{eff} values with various bond lengths and this would give water its very special properties [L27]. Even flux tubes without any particles but serving as topological space-time correlates and even prerequisistes of entanglement between atoms are possible.

The hydrogen atom can form a bond between two atoms. Usually, the hydrogen forms a hydrogen bond with the first atom and valence bond with the second atom. This applies for large distances for which hydrogen bond is weak. At short distances hydrogen bond becomes stronger and it has been found that hybrids of hydrogen- and valence bonds between between two fluorine atoms - hydrogen-mediated chemical bonds - have been observed (`https://cutt.ly/Snetr52`).

In the TGD framework, the hybrids could be understood as a delocalization of both electron and proton to the two bonds involved. For short bond lengths, the proton would not be delocalized and for long bond lengths the electron would not be delocalized.

3.2 Water oxidation and photosynthesis in TGD framework

These comments were inspired by an interesting article "Isolating an elusive missing link" (`https://cutt.ly/dng7My6`) about water oxidation. It came as a surprise to me that water oxidation is still a poorly understood piece of biochemistry. Bio-chemists believe that they understand various aspects of the reaction reasonably well with one exception, which is the formation of the O_2 molecule in water oxidation and the article tells about progress in this respect.

The water oxidation reaction (WOR) is one of the most important reactions on the planet since it is a key step in photosynthesis and is also the source of nearly all the atmosphere's oxygen. What is so beautiful is that both photosynthesis as a chemical storage of the solar energy and water oxidation producing oxygen essential for aerobic respiration to utilize the stored energy, are parts of the same process.

Understanding the intricacies of WOR can hold the key to improve the efficiency of the reaction which could be utilized to produce hydrogen. As the article tells, the reaction's chemical mechanisms are complex and the intermediates highly unstable. This makes their isolation and characterisation extremely challenging. To overcome this, scientists are using molecular catalysts as models to understand the fundamental aspects of water oxidation — particularly the oxygen-oxygen bond-forming reaction.

WOR (see `https://cutt.ly/Jng72R8` and `https://cutt.ly/Ang781b`) forms an essential part of photosynthesis (`https://cutt.ly/Tng77R4`). What happens in WOR is that two water molecules split $4H^+$,$4e^-$, and O_2. The reaction mechanism is not completely understood. Somehow the solar radiation induces the process in which two H_2O molecules split to $4H^+$, $4e^-$, and O_2. The 4 electrons are utilized in photosynthesis in the KOK cycle.

In the sequel a general mechanism of catalysis inspired by zero energy ontology (ZEO) [L31] is discussed. In this approach biocatalysis involves two "big" state function reductions (BSFRs) changing the arrow of time. The first BSFR induces time reversed time evolution leading from the final of a sub-reaction kicking the reactants over the potential wall preventing the reaction from occurring. After the second BSFR the time evolution continues from the initial state of time reversed time evolution in standard time direction. The catalytic process takes place spontaneously and the role of the catalyst is to make the spontaneous occurrence in the reversed time direction possible and probable enough. Quantum coherence in long scales is necessary and the identification of dark matter as $h_{eff} = nh_0$ phases implied by adelic physics predicts it [L29].

3.3 Basic facts about photosynthesis and water splitting

Photosynthesis involves two parts. The first part does not involve photons and leads to the splitting of water producing from two water molecules 4 protons and 4 electrons plus O_2 molecule. The second part involving photons stores their energy chemically. The first part occurs in oxygen evolbing complex (EOC), known also as water splitting complex, and acting as a cofactor of photosystem II enzyme in which the photosynthesis proper takes place.

3.3.1 Oxygen evolving (water splitting) complex (OEC)

OEC is the cofactor of photosystem II enzyme. OEC has an inorganic core obeying the empirical chemical formula $Mn_4Ca_{1O}O_xCl_{1-2}(HCO_3)_y$ core. Core is surrounded by 4 protein subunits of photosystem II at membrane-lumen interface.

OEC functions as follows.

i. The extraction of 4 electrons and and hydrogen ions from 2 water molecules produces O_2 molecule as a kind of waste.

ii.

iii. OCE transfers 4 electrons, one at a time, to photosystem II via a tyrosine residue in the reaction center. Photosystem II must store the energy of 3 photons before the fourth one provides sufficient energy for water oxidation. Kok theory states that OEC can exist in 5 states $S0, ..., S4$. $S4$ since OEC has lost 4 electrons. $S0$ is the most reduced.
$S4$ is unstable to reset to ground state $S0$ and reacts with water producing free oxygen. OEC receives the 4 electrons and returns to state S_0.

iv. After that photons from photosystem II drive the system from $S0$ to $S4$. The electrons from OEC are transferrred to photosystem II one-by-one. Photons from photosystem II energize electrons which are driven through the a variety of coenzymes and cofactors to reduce plastoquinone to plastoquinol.

v. The 4 hydrogen ions are used to create a proton gradient. This means that they are driven against the membrane potential gradient and gain potential energy liberated later as the protons return back and provide electrostatic energy used to by ATP synthase to transfrom ADP to ATP.

3.3.2 The energetics of photosynthesis

Consider first the energetics of photosynthesis (https://cutt.ly/Tng77R4).

i. As far the energetics is considered, the process of photosynthesis is equivalent to $CO_2 + 2H_2O + \gamma \rightarrow CH_2O + O_2 + H_2O$. What happens to the 4 electrons and protons produced in the splitting of water?

ii. CO_2 loses one O and CO combines with two protons and electrons to form CH_2O. This requires a catalyst to temporarily kick out O from CO_2. This energy is returned to the catalyst when two electrons and protons combine with O to form H_2O. The binding energy of C=O bond and H=O bond are indeed nearly the same.

iii. Water splitting requires energy $E = 4E_B(O-H) + 4E_B(e-p) = 4 \times (5.15 + 13.6)$ = eV. The formation of $O = O$ provides energy $E_B(O = O) = 5.13$ eV. In the formation of H_2O $2 \times (5.15 + 13.6)$ eV is returned to the catalyst but this energy has been already taken into account and compensates for the energy needed to split CO_2. Therefore the energy $E_1 = 4(E_B(O-H) + E_B(e-p)) - E_B(O=O) = [4 \times (5.15 + 13.6) - 5.13]$ eV needed from catalyst must correspond the energy liberated in the formation of CH_2O. This is true assuming that the binding energy of e and p associated in the O-H valence bond is the sum of atomic binding energy and O-H bond energy.
The formation of CH_2O involves combination of 2 protons and electrons to form two hydrogens, the atomic binding energy $2E_B(\text{e-p}) = 2 \times 13.6$ eV is liberated in the formation of CH_2O and compensates the same energy appearing in E_1. Hence the atomic binding energies can be forgotten in the energy budget and it is enough to compare only the molecular binding energy E_2 in E_1 with E_B. The molecular contribution to E_1 is $E_2 = 4 \times 5.15 - 5.13$ eV = 15.48 eV.

iv. The formation of CH_2O means a generation of molecular binding energy which is approximately the sum of $O{=}CH_2$ binding energy and C-H binding energies. Besides this atomic binding energy of two hydrogen atoms is liberated. The liberated molecular binding energy is $E_B(CH_2O) = E_B(O = CH_2) + 2 \times E_B(C-H) = (7.75 + 2 \times 4.28)$ eV= 16.31 eV. The amount of the liberated molecular binding energy is $E_B(CH_2O) = 16.31$ eV and is by .83 eV larger than $E_2 = 15.48$ eV. One must drive 4 protons against a potential gradient and this requires energy $4 \times .07eV = .28$ eV which is smaller than this energy. 4 photons are used and if their energies are about 2 eV they provide 8 eV.

v. This estimate does not take thermodynamics and second law into account. Since pressure and temperature can be assumed to stay constant in the process, the thermodynamical approach using Gibbs free energy $G = E + pV - TS$ as thermodynamical function is natural. $dG = VdP - SdT + \sum_i \mu_i dN_i$ reduces to $dG = \sum_i \mu_i dN_i$ if pressure and temperature are constant.

vi. The overall process can be written as $6CO_2 + 6H_2O + \text{light} \rightarrow C_6H_{12}O_6 + 6O2$. This form corresponds to a polymerization of 6 CH_2O molecules to form sugar $C_6H_{12}O_6$.

vii. Several separate steps are involved with photosynthesis besides the splitting of water; there are 4 steps corresponding to the transfer of electron decomposing to substeps related to the photosynthesis proper. Each of this steps involves catalysis.

That two water molecules are involved in the basic process, could also be essential. The hydrogen bond between the water molecules or its dark variant could play some role.

3.4 TGD view about water photosynthesis and water oxidation

TGD provides a new view about bio-catalysis in which the magnetic body (MB) acts as a controller. One might hope that at this level the description of the biocatalysis is much simpler than at the level of biochemistry. Therefore one can ask whether a simple overall view based on the energetics and the notion of MB carrying dark matter at

its flux tubes could help. Since 5 different kinds of valence bonds must be temporarily split in the overall reaction, a catalyst providing the needed energy to temporarily break the valence bonds is needed.

There are many other steps involving catalysis and the actual situation taking into account reactions involving photons is extremely complex. From the foregoing it is clear that the splitting of water requires 75 eV energy. Most of this energy is related to the ionization of hydrogen atoms. Note however that valence electrons in the valence bonds are approximated as ordinary atomic electrons. Unless quantum tunnelling is involved, this energy must be provided by some source.

3.4.1 Does time reversal provide a general mechanism of bio-catalysis?

In the TGD framework one can consider 3 general mechanisms of biocatalysis and both mechanisms could be involved.

The basic problem in the understanding of catalysis is to identify the mechanism kicking the reactants over the potential wall making the reaction extremely slow. How to get over this potential wall is even rid of it?

Zero energy ontology (ZEO) [L31, L29, L33] suggests a completely general mechanism of biocatalysis.

i. ZEO is behind the TGD inspired quantum measurement theory and makes it possible to resolvin the basic paradox of standard quantum measurement theory and gives rise to a quantum theory of consciousness. The new element is that the arrow of time changes in ordinary ("big") state function reduction (BSFR), whereas it remains unchanged in "weak" measurements, "small" state function reductions (SSFR).
   In ZEO, BSFR creates a superposition of time reversed deterministic classical time evolutions analogous to Bohr orbits and leading from the final state to the geometric past. The findings of Minev et al [L28] support the notion of BSFR [L28].

ii. BSFR has far reaching implications. Since water splitting has turned out to be very difficult to understand, a natural question is whether BSFR could explain it. If water splitting occurs as BSFR, it would correspond to a spontaneously occurring process $4e+4p+ O_2 \rightarrow H_2O$ in reversed time direction requiring no catalysis. Second BSFR would mean a return to a moment of geometric time where one as $4e+4p+O_2$.

iii. BSFRs could be involved also with the other steps involving the splitting of chemical bonds and make it possible to kick the reactants over the potential wall. In a reversed time direction this process would take place spontaneously and lead from free atoms to their bound states by generation of atomic and molecular bonds.

iv. BSFR is especially natural in the situations in which the reverse process occurs spontaneously meaning that only the process but not its reversal involves potential wall. This seems to be the case in bio-catalysis. In nuclear reactions the situation is different since both the process and its reversal involve overcoming of a Coulomb wall.

The ZEO based vision provides only a general idea about what is involved with a given catalytic step of a given step of say photosynthesis but tells nothing of its chemical details, in particular of the role of MB and dark particles at it. The chemistry of water oxidation catalyst - oxygen evolving complex - is extremely complex but a general principle might considerably facilitate its understanding.

3.4.2 How to model the reverse time evolution behind catalysis as ordinary time evolution?

The most plausible option is that water oxidation and also other steps involving liberation of atoms from bound states take place via BSFR. The ZEO based view about biocatalysis does not however exclude the modelling of the time reversed process as

occurring in the standard direction of time and being based on some catalytic mechanism. The presence of the catalyst would make the BSFR possible. This kind of modelling would help to characterize the catalyst and the superposition of time reversed time evolutions leading to the final state as time evolutions with standard time direction.

i. The first mechanism involves a reduction of h_{eff} for a magnetic flux tube liberating energy temporarily kicking the system over the potential wall. That energy is liberated follows from the fact that energies in general increase with h_{eff}. The reduction of the cyclotron energy proportional to h_{eff} of the charged particles at the flux tube would liberate the needed energy.
This mechanism might make sense in the case of molecular binding energies of order few eV which is the energy scale for the cyclotron energies in the magnetic field $B_{end} = .25$ eV for $h_{eff} = h_{gr} = GMm/v_0$.
This mechanism could apply to the catalytic steps of photosynthesis separately. If it applies to water oxidation, the energy 75 eV provided by flux tubes would be returned gradually to the catalyst (shortened magnetic flux tube) during photosynthesis proper as electrons and protons bind to the hydrogen atoms of COH_2 and H_2O during the process.

ii. Second, much more speculative (even in TGD framework), mechanism would be a phase transition increasing the thickness of a magnetic flux tube liberating magnetic and volume energy [L34] suggested to be behind the proposed rather rapid expansion of the Earth increasing its radius by factor 2 and leading to Cambrian explosion. This transition would scale up the value of h_{eff} for valence electrons by factor of 2 and reduce the bond energies by factor 1/4 and also the energy of electron of hydrogen atom.
This mechanism could be behind the proposed model of quantum tunneling in-nuclear reactions [L30]. The quantum tunnelling would involve BSFR as a phase transition increasing the value of h_{eff} and size scale of the colliding nuclear strings. These dark nuclei would have dramatically reduced binding energy and increased spatial scale making it possible to overcome the Coulomb barrier. The reactions would proceed fast in the dark phase and the second BSFR would transform dark nuclei to ordinary nuclei.
"Cold fusion" would rely on this mechanism except that now the protons would be transformed to dark protons by the analog of Pollack effect, and there is no need to break nuclear bonds as in ordinary nuclear reactions [L13, L32]. Also in the case of nuclear quantum tunnelling the phase transition would be scaling of flux tubes.
The basic objection is that the phase transition would reduce the energy scale of valence electrons of all atoms involved. This does not look realistic.

1. Shortening of flux tubes by a reduction of h_{eff}

How could the bio-catalysis assisted by MB proceed? MB should provide the energy needed to split the bonds of various molecules. Could the reduction of h_{eff} for cyclotron states at dark magnetic flux tubes liberate cyclotron energy of charged particles at them proportional to h_{eff}?

i. The magnetic cyclotron energy $E_c = \hbar_{eff} ZeB/m$ is large for large $\hbar_{eff}$. Magnetic energies for $h_{eff} = h$ are rather small. Also for relatively small values of $h_{eff} > h$ assignable to valence bonds, the cyclotron energies for proton and electron are much smaller than atomic binding energies for reasonable values of the magnetic field.

ii. The basic proposal which led to the h_{eff} vision is that in TGD framework large values of h_{eff} allowing cyclotron energy in an endogenous magnetic field $B_{end} \simeq .2$ Gauss to be in visible and UV range are possible. The value of h_{eff}/h of order 10^{14} is needed. Nottale hypothesis

$$\hbar_{eff} = \hbar_{gr} = \frac{GMm}{v_0} \quad ,$$

One has $v_0 = 1/2$ in the simplest model - implying that gravitational Compton length equals to the Schwartschild radius $r_S \simeq 1$ cm of the Earth - implies that cyclotron energies do not depend on the mass of small particle, in particular they are same for all charged particle with given charge if the value of B is same.

iii. Dark protons at magnetic flux tube are a basic building brick of TGD inspired quantum biology. Could the liberation of cyclotron energy for dark protons (or for dark ions) allow to break O-H bonds and ionize hydrogens? Could some dark protons (or ions) transform temporarily to ordinary protons and liberate their cyclotron energy propto h_{gr} so that MB could act as a bio-catalyst.

iv. The general view of bio-catalysis suggests that the eventual formation of the final state molecules liberates energy, which increases the value of h_{eff} of dark flux tubes to its original value. Note that the energy of the final state is by .83 eV smaller than that of the initial state so that dissipative losses are possible even if the entire energy of the photon is stored as metabolic energy.

2. Could the thickening of flux tubes liberate energy and reduce atomic binding energy scale?

Although this option does not look realistic, it deserves a more detailed treatment.

i. The phase transition, which increases the radius of magnetic flux tubes by a power of 2 (by p-adic length scale hypothesis), liberates energy and could induce an increase of h_{eff} at the level of valence electrons and reduce the binding energy scale of the valence electrons proportional to $1/h_{eff}^2$ by a factor $1/2^{2k}$. This mechanism was discussed in [L34].

ii. The energy of 75 eV would be reduced to about $75/2^{2k}$ eV. $k = 1$ would give 18.8 eV and $k = 2$ would give 4.7 eV. The reduction of the binding energy would be due to the energy liberated in the thickening of the magnetic flux tubes. Water would be special in the sense that these phase transitions could occur for the magnetic flux tubes assignable to water and explain its multiphase character responsible for its numerous thermodynamic anomalies.

iii. What is the scale of the flux tubes involved? Suppose that a flux tube portion of radius L and roughly the same length is involved. If the energy E of is of order $E \sim \hbar_{eff}/L$, the length scale would be about $L = (h/h_{eff} \times 1.6$ nm. For $h_{eff} = h$, the length scale corresponds to cell membrane thickness. The outcome of this process would be a reduction of the scale of valence electron binding energies and of bond energies. In this phase the required reactions could proceed easily.

4 Biocontrol and supraphases

4.1 A New Control Mechanism Of TGD Inspired Quantum Biology

The idea that TGD Universe is quantum critical, is the corner stone of quantum TGD and fixes the theory more or less uniquely since the only coupling constant parameter of the theory - Kähler coupling strength - is analogous to critical temperature. Also more than one basic parameters are in principle possible - maximal quantum criticality fixes the values of all of them - but it seems that only Kähler coupling strength is needed. TGD Universe is a quantum critical fractal: like a ball at the top of hill at the top of hill at.... Quantum criticality allows to avoid the fine tuning problems plaguing as a rule various unified theories.

4.1.1 Quantum criticality

The meaning of quantum criticality at the level of dynamics has become only gradually clearer. The development of several apparently independent ideas generated for about decade ago have led to the realization that quantum criticality is behind all of them. Behind quantum criticality are in turn number theoretic vision and strong forms of general coordinate invariance and holography.

i. The hierarchy of Planck constants defining hierarchy of dark phases of ordinary matter corresponds to a hierarchy of quantum criticalities assignable to a fractal hierarchy of sub-algebras of super-symplectic algebra for which conformal weights are n-ples of those for the entire algebra, n corresponds to the value of effective Planck constant $h_{eff}/h = n$. These algebras are isomorphic to the full algebra and act as gauge conformal algebras so that a broken super-conformal invariance is in question.

ii. Quantum criticality in turn reduces to the number theoretic vision about strong form of holography. String world sheets carrying fermions and partonic 2-surfaces are the basic objects as far as pure quantum description is considered. Also space-time picture is needed in order to test the theory since quantum measurements always involve also the classical physics, which in TGD is an exact part of quantum theory.
Space-time surfaces are continuations of collections of string world sheets and partonic 2-surfaces to preferred extremals of Kähler action for which Noether charges in the sub-algebra of super-symplectic algebra vanish. This condition is the counterpart for the reduction of the 2-D criticality to conformal invariance. This eliminates huge number of degrees of freedom and makes the strong form of holography possible.

iii. The hierarchy of algebraic extensions of rationals defines the values of the parameters characterizing the 2-surfaces, and one obtains a number theoretical realization of an evolutionary hierarchy. One can also algebraically continue the space-time surfaces to various number fields - reals and the algebraic extensions of p-adic number fields. Physics becomes adelic. p-Adic sectors serve as correlates for cognition and imagination. One can indeed have string world sheets and partonic 2-surfaces, which can be algebraically continued to preferred extremals in p-adic sectors by utilizing p-adic pseudo constants giving huge flexibility. If this is not possible in the real sector, figment of imagination is in question! It can also happen that only part of real space-time surface can be generated: this might relate to the fact that imaginations can be seen as partially realized motor actions and sensory perceptions.

4.1.2 Quantum criticality and TGD inspired quantum biology

In TGD inspired quantum biology quantum criticality is in crucial role. First some background.

i. Quantum measurement theory as a theory of consciousness is formulated in zero energy ontology (ZEO) and defines an important aspect of quantum criticality. Strong form of NMP states that the negentropy gain in the state function reduction at either boundary of causal diamond (CD) is maximal. Weak form of NMP allows also quantum jumps for which negentropic entanglement is not generated: this makes possible ethics (good and evil) and morally responsible free will: good means basically increase of negentropy resources.

ii. Self corresponds to a sequence state function reductions to the same boundary of CD and h_{eff} does not change during that period. The increase of h_{eff} (and thus evolution!) tends to occur spontaneously, and can be assigned to the state function reduction to the opposite boundary of CD in zero energy ontology (ZEO). The reduction to the opposite boundary means death of self and living matter is fighting in order to avoid this even. To me the only manner to make sense about basic myth of Christianity is that death of self generates negentropy.

iii. Metabolism provides negentropy resources for self and hopefully prevents NMP to force the fatal reduction to the opposite boundary of CD. Also homeostasis does the same. In this process self makes possible evolution of sub-selves (mental images dying and re-incarnating) state function by state function reduction so that the negentropic resources of the Universe increase.

4.1.3 A new mechanism of quantum criticality

Consider now the mechanisms of quantum criticality. The TGD based model [L5] [K19] (`http://tinyurl.com/y8oblpl9`) for the recent paradoxical looking finding [L5] (`http://tinyurl.com/y79qo7lp`) that topological insulators can behave like conductors in external magnetic field led to a discovery of a highly interesting mechanism of criticality, which could play a key role in living matter.

i. The key observation is that magnetic field is present. In TGD framework the obvious guess is that its flux tubes carry dark electrons giving rise to anomalous currents running in about million times longer time scales and with velocity, which is about million times higher than expected. Also supra-currents can be considered.
The currents can be formed of the cyclotron energies of electrons are such that they correspond to energies near the surface of the Fermi sphere: recall that Fermi energy for electrons is determined by the density of conduction electrons and is about 1 eV. Interestingly, this energy is at the lower end of bio-photon energy spectrum. In the field of 10 Tesla the cyclotron energy of electron is .1 mV so that the integer characterizing cyclotron orbit must be $n \simeq 10^5$ if conduction electron is to be transferred to the cyclotron orbit.

ii. The assumption is that external magnetic field is realized as flux tubes of fixed radius, which correspond to space-time quanta in TGD framework. As the intensity of magnetic field is varied, one observes so called de Haas-van Alphen effect (`http://tinyurl.com/ych7b9n8`) used to deduce the shape of the Fermi sphere: magnetization and some other observables vary periodically as function of $1/B$ (for a model for the quantum critical variant of the effect see [D6]).
This can be understood in the following manner. As B increases, cyclotron orbits contract. For certain increments of $1/B$ $n+1$:th orbit is contracted to n:th orbit so that the sets of the orbits are identical for the values of $1/B$, which appear periodically. This causes the periodic oscillation of say magnetization.

iii. For some critical values of the magnetic field strength a new orbit emerges at the boundary of the flux tube. If the energy of this orbit is in the vicinity of Fermi surface, an electron can be transferred to the new orbit. This situation is clearly quantum critical.
If the quantum criticality hypothesis holds true, $h_{eff}/h = n$ dark electron phase can be generated for the critical values of magnetic fields. This would give rise to the anomalous conductivity perhaps involving spin current due to the spontaneous magnetization of the dark electrons at the flux tube. Even super-conductivity based on the formation of parallel flux tube pairs with either opposite or parallel directions of the magnetic flux such that the members of the pair are at parallel flux tubes, can be considered and I have proposed this a mechanism of bio-superconductivity and also high Tc super-conductivity.

4.1.4 A new mechanism of quantum bio-control

The quantum criticality of the process in which new electron orbit emerges near Fermi surface suggests a new mechanism of quantum bio-control by generation of super currents or its reversal.

i. In TGD inspired quantum biology magnetic body uses biological body as motor instrument and sensory receptor and EEG and its fractal variants with dark photons with frequencies in EEG range but energy $E = h_{eff}f$ in the range of bio-photon energies make the necessary signalling possible.

ii. Flux tubes can become braided and this makes possible quantum computation like processes [K16]. Also so called 2-braids - defined by knotted 2-surfaces imbedded in 4-D space-time surface - are possible for the string world sheets defined by flux tubes identified to be infinitely thin, are possible. As a matter fact, also genuine string world sheets accompany the flux tubes. 2-braids and knots are purely TGD based phenomenon and not possible in superstring theory or M-theory.

iii. It is natural to speak about motor actions of the magnetic body. It is assumed that the flux tubes of the magnetic body connect biomolecules to form a kind of Indra's web explaining the gel like character of living matter. h_{eff} reducing phase transitions contract flux tubes connecting biomolecules so that they can find each other by this process and bio-catalysis becomes possible. This explains the mysterious looking ability of bio-molecules to find each other in the dense molecular soup. In fact the dark matter part is far from being soup! The hierarchy of Planck constants and $h_{eff} = h_{gr}$ hypothesis imply that dark variants of various particles with magnetic moment are neatly at their own flux tubes like books in shelf.
Reconnection of the U-shaped flux tubes emanating from two subsystems generates a flux tube pair between them and gives rise to supracurrents flowing between them. Also cyclotron radiation propagating along flux tubes and inducing resonant transitions is present. This would be the fundamental mechanism of attention.

iv. I have proposed that the variation of the thickness of the flux tubes could serve as a control mechanism since it induces a variation of cyclotron frequencies allowing to get in resonance or out of it. For instance, two molecules could get in flux tube contact when the cyclotron frequencies are identical and this can be achieved if they are able to vary their flux tube thickness. The molecules of immune system are masters in identifying alien molecules and the underlying mechanism could be based on cyclotron frequency spectrum and molecular attention. This would be also the mechanism behind water memory and homeopathy (`http://tinyurl.com/yda3d6se` [K5] which still is regarded as a taboo by mainstreamers.

v. Finally comes the promised new mechanism of bio-control. The variation of the magnetic field induced by that of flux tube thickness allows also to control whether there is quantum criticality for the generation of dark electron supra currents of electrons. The Fermi energy of the conduction electrons at the top of Fermi sphere is the key quantity and dictated by the density of these electrons. This allows to estimate the order of magnitude of the integers N characterizing cyclotron energy for ordinary Planck constant and the maximal value of $h_{eff}/h = n$ cannot be larger than N.

4.2 Are Bacteria Able To Induce Super-Fluidity?

Nature News (see `http://tinyurl.com/nhcmkle`) tells t hat a team led by Auradou et al reports in the article "Turning Bacteria Suspensions into Superfluids" [I3] published in Phys Rev Letters (see `http://tinyurl.com/ycfm8gnn`) that bacterium swimming in fluid do not only reduce its viscosity associated with shear stress (viscous force parallel to the surface) but makes it to behave in super-fluid like manner above a critical concentration of bacteria.

As the number of bacteria (E. coli) was increased, the viscosity associated with shear stress (the viscous force parallel to the surface) dropped: this in accordance with theoretical expectations. Adding about 6 billion cells (the fluid volume is not mentioned but it seems that the effect occurs above critical density of bacteria), the apparent viscosity dropped to zero - or more precisely, below the experimental resolution. The super-fluid like behavior was preserved above the critical concentration. What is important that this did not happen for dead bacteria: bacteria play an active role in the reduction of viscosity.

Researchers are not able to identify the mechanism leading to the superfluid-like behavior but some kind of collective effect is believed to be in question. The findings suggest that the flagellae - kind of spinning hairs used by the bacteria to propel them-

selves - should play an essential part in the phenomenon. As bacteria swim, they fight against current, decreasing the local forces between molecules that determine the fluid's viscosity. Above critical density the local effects would somehow become global.

Cates et al have proposed this kind of phenomenon: see the article "Shearing Active Gels Close to the Isotropic-Nematic Transition" (see `http://tinyurl.com/y9e3xl9v`) [I5]. The authors speak in the abstract about zero apparent viscosity.

i. The title of the article of Cates et al tells that the phenomenon occurs near isotropic-nematic transition. Nematic is defined as a liquid crystal for which the molecules are thread-like and parallel. I dare guess that in the recent case the approximately parallel flagellae would be modelled as liquid crystal like 2-D phase at the surface of bacterium. In the isotropic phase the orientations of the flagellae would be uncorrelated and long range orientational correlations would emerge in the phase transition to nematic phase.

ii. Also the notions of contractile and extensile gels are introduced. Contraction and extension of gels are though to occur through molecular motors. The transformation of the fluid to apparent superfluid would require energy to run the molecular motors using metabolic energy and ordinary superfluidity would not be in question.

iii. The model predicts divergence of viscosity for contractile gels. For extensile gels a zero of apparent viscosity is predicted. There is a hydrodynamical argument for how this would occur but I did not understand it. The active behavior of the bacteria would means that the gel like surface phase (nematic liquid crystal) formed by the flagellae extends to reduce viscosity. If I have understood correctly, this applies only to the behavior of single bacterium and is about the reduction of viscosity in the immediate vicinity of cell.

My deep ignorance about rheology allows me freedom to speculate freely about the situation in TGD framework.

i. In TGD inspired biology gel phase corresponds to a phase, which involves flux tube connections between basic units. Flux tubes contain dark matter with non-standard value $h_{eff} = n \times h$. The h_{eff} changing phase transitions scaling the lengths of flux tubes proportional to h_{eff} are responsible for the contractions and extensions of gel.
   The extension of the gel should lead to a reduction of viscosity since one expects that dissipative effects are reduced as h_{eff} increases and quantum coherence is established in longer scales. Large h_{eff} phases are associated with criticality. Now the criticality would be associated with isotropic-nematic phase transition. The parallelization of flagellae would be due to the quantum coherence assignable with the flagellae.
   Note that the mechanism used by bacteria to control the liquid flow would be different since now molecular motors are replaced by h_{eff} changing phase transitions playing key role in TGD inspired view about biochemistry. For instance, reacting biomolecules find each other by h_{eff} reducing phase transition contracting the flux tubes connecting them.

ii. This model does not yet explain the reduction of apparent viscosity to zero in the entire fluid occurring above a critical density of bacteria. What could happen could be analogous to the emergence of high T_c superconductivity according to TGD [K9] (`http://tinyurl.com/ycm6ao76`). Below pseudo gap temperature the emergence of magnetic flux tube pairs makes possible super-conductivity in short scales. At critical temperature a phase transition in which flux tubes reconnect to form larger thermodynamically stable networks occurs. One can speak about quantum percolation.
   The reduction of viscosity for a single bacterium could be based on the phase transition of liquid molecules to dark molecules flowing along the resulting flux tubes with very small friction (large $heff$) but only below certain scale smaller than the typical distance between bacteria. This would be the analog for what happens below pseudo gap. Above critical density he magnetic flux tubes associated with bacteria

would reconnect and forming a net of connected flux tube paths at scale longer than inter-bacterial distances. This would be the counterpart for the emergence of superconductivity by percolation in long scales.

4.3 Bacteria behave like spin system: Why?

In Physorg there was an interesting article titled "Bacteria streaming through a lattice behave like electrons in a magnetic material" (see `http://tinyurl.com/hysxsl6`). The popular article tells about article with title Ferromagnetic and antiferromagnetic order in bacterial vortex lattices by Dunkel et al [I7] (see `http://tinyurl.com/ydbzvmcc`) . The following summarizes what has been studied and observed.

i. The researchers have studied a square lattice of about 100 wells with well radius below 50 microns and well depth about 18 microns. The wells are connected by thin channels. Also triangular lattice has been studied.

ii. Below a critical radius about 35 microns an ordered flow is generated. The flow involves interior flow and edge flow in opposite direction consisting of single bacterium layer. One can understand this from angular momentum conservation. The coherence of this flow is however surprising. If one believes that each bacterium in principle chooses its swimming direction, one must understand what forces bacteria to select the same swimming direction.

iii. Below a critical radius of channel about d=4 microns the flow directions in the neighboring wells are opposite for the square lattice. One has superposition of lattice and its dual with opposite flow directions. In the case of triangular lattice analogous cituation is encountered. In this situation there is no flow between the wells but there is an interaction. The minimization of dissipative losses requires minimization of velocity gradients inside channels. made possible by same local flow direction for the edge currents of neighboring wells.

iv. Above the critical radius the flow changes its character. The flows synchronize and the interior flows rotate in the same direction as do also edge flows which occur also between the neighboring channels and give rise to closed flows around the boundaries of square like regions behind wells having larger scale. This flow pattern is consistent with angular momentum conservation: the angular momenta of lattice and its dual cancel each other.

v. The phase transition is analogous to that from antiferromagnetism to ferromagnetism. The total angular momenta of bacteria, their colonies, are analogous to spins. The situation can be modelled as 2-D Ising model consisting of lattice of spins with nearest neighbor interactions. Usually the spins are assigned with electrons but now they are assigned with bacteria.

This raises interesting questions. Bacteria swim by using flagellae. They can decide the swimming direction and control it by controlling the flagellae. Bacteria are living organisms and have a free will. Why would bacterium colory behave like quantal many-spin system. What happens when the swimming direction becomes same for the bacteria inside single well: does the colony become an entity with collective consciousness and do bacteria obey "social pressure". Does this happen also for the colony formed by these colonies in transition to ferromagnetism like state?

If one takes TGD inspired quantum biology as starting point, one can represent more concrete questions and possible answers to them.

i. Magnetic body (MB) controls the biological body (BB) be it organism or part of it [K19]. MB contains dark matter as cyclotron Bose-Einstein condensates of bosonic ions. Pairs of parallel flux tubes could also contain members of Cooper pairs whose spin depends on whether the magnetic fields at flux tubes are parallel or antiparallel [K8, K9].

ii. What could be the mechanism of control? MB is assumed to send dark photon signals from MB to biological body to control it and an attractive idea is that control is by angular momentum conservation. Since the angular momentum transfer

involve is due to a phase transition analogous to the change of the direction of magnetization or generation of magnetization the angular momentum transfer is large irrespective of the value of unit of angular momentum for dark photon (see discussion below). This large angular momentum could be transformed to angular momentum of ordinary matter and in recent case be responsible for generating the rotational motion of bacterium or larger unit.
The transfer of dark photons induced by a phase transition changing the direction of dark magnetization might thus induce a large transfer of angular momentum to BB and generate macroscopic rotation. If this were the case the rotational state of dark MB of bacterium would serve as a template for bacterium.
The bacterium colony associated with the well below critical size would correspond to super-organism having MB whose rotational state could serve as template for the bacterial MBs in turn serving as a similar template for the bacteria.

iii. If the net angular momenta of MB and corresponding BB (bacterium, well colony, colony of these) vanish separately, the model is consistent with the model of the article in which local considerations determine the rotational directions. In this case the MBs of well colonies would behave like spins with nearest neighbor interactions. One can also consider the possibility that at quantum criticality long range quantum fluctuations occur and the local equilibrium conditions do not hold true. Even more, the net angular momenta of MB and BB would cancel each other but would not necessarily separately. This would imply apparent non-conservation of angular momentum at the level of bacterium colony at criticality and might allow to find experimental support for the notion of magnetic body. The proof of MB carrying dark matter as a concept would be very much like that of neutrino the existence of which was deduced from apparenent energy non-conservation in beta decays.

The model has a problem to worry about. I still am not quite sure whether $h_{eff}/h = n$ means that the unit of spin is scaled up by n or that a fractionization of angular momentum by $1/n$ for single sheet of associated n-fold covering of space-time surface takes place. The control mechanism based on angular momentum conservation could however be at work in both cases. The option assuming fractionization seems to be the realistic one and only this will be considered in the following. Reader can ponder the option assuming scaled up unit of angular momentum (the scaling up of angular momentum of dark photon is not in coherence with the assumption that dark photon has same four-momentum as ordinary photon to which it should be able to transform).

i. Consider first the simplest variant for the effective fractionization of quantum numbers. If one has n-fold covering singular at the boundaries of CD then spin fractionization can be considered such that one has effectively n spin $1/n$ photons - one per sheet - and the net spin is just the standard spin. This picture fits with the vision that the n-fold covering means that one must make n full 2π turns before turning to the original point at space-time sheet: this allows at space-time surface wave functions with fractional spin which would be many-valued in Minkowski space. Similar fractionization would occur to other quantum numbers such as four-momentum so that net four-momentum would not change. The wavelength of these building bricks of dark photon analogous to Bose-Einstein condensate have frequencies scaled down by factor $1/n$.
In this case the direct decay to single ordinary photon interpreted as bio-photon is allowed by conservation laws. Of course, also decays to several ordinary photons are possible. The decay to a bunch of n ordinary photons with total momenta $1/n$ times that of dark photon is possible if the spins of ordinary photons sum up to the spin of dark photon.
The total angular momentum liberated from the cyclotron Bose-Einstein condensate spin could be transferred to spin of ordinary particles, say proton or ion for which the natural scale of orbital angular momentum is much larger (proportional to the rest energy). Simple order of magnitude estimate for orbital angular momentum with respect to the symmetry axis of possibly helical magnetic flux tube shows that in this case the spin could be transformed to angular momentum in the scale of

organism and to the motion of organism itself.
Note that dark photon could also decay to a bunch of ordinary photons with momentum scaled down by $1/n$ since the spins of the photons can sum up to spin 1.

ii. A many-sheeted analog of second quantization generalizes the above picture. The n space-time sheets can be labelled by an integer $m = 1, ..., n$ defining an analog of discrete position variable. One can second quantize the fundamental fermions in this discrete space so that one has not only the ordinary many fermion states with $N = 0/1$ fermions in given mode but also states with fractionization of fermion number and other quantum numbers by $q = m/n < 1$ in a given mode. This would induce fractionization of bosons identified as fractional many-fermion states.
Particle with fractional spin cannot decay directly to ordinary particle unless one has m=n: this correspond to the first option. Fractional particles characterized by q and 1-q can however fuse to ordinary particle. An attractive additional hypothesis is that the net quantum numbers are integer multiples of the basic unit.
I have discussed the possibility of molecular sex: the opposite molecular sexes would have fractional charges summing up to ordinary charges. If magnetic bodies with opposite molecular sexes are paired they have ordinary total quantum numbers and can control ordinary matter by the proposed mechanism based on conservation of angular momentum (or some other charges). Dark matter would serve as template for ordinary matter and dark phase transitions would induce those of visible matter. The proposal that DNA, RNA, tRNA, and amino-acids are accompanied by dark proton sequences (or more general dark nuclei) could realize this picture. DNA double strand could be seen as an outcome of a molecular marriage in this framework! At higher level brain hemispheres might be a seen as a dark matter marriage. This picture can be also seen as emergence of symbols and dynamics based on symbol sequences at the molecular level with molecular marriage making possible very precise selection rules.

5 Dark variants of basic information molecules

Two highly interesting findings providing insights about the origins of life have emerged and it is interesting to see how they fit to the TGD inspired vision.

The group led by Thomas Carell has made an important step in the understanding the origins of life. They have identified a mechanism leading to the generation of purines A and G which besides pyrimidines A,T (U) are the basic building bricks of DNA and RNA. The crucial step is to make the solution involved slightly acidic by adding protons. For year later I learned that a variant of Urey-Miller experiment with simulation of shock waves perhaps generated by extraterrestrial impacts using laser pulses generates formamide and this in turn leads to the generation of all 4 RNA bases.

These findings represent a fascinating challenge for TGD inspired quantum biology. The proposal is that formamide is the unique amide, which can form stable bound states with dark protons and crucial for the development of life as dark matter-visible matter symbiosis. Pollack effect would generate electron rich exclusions zones and dark protons at magnetic flux tubes. Dark protons would bind stably with unique amine leaving its chemical properties intact. This would lead to the generation of purines and the 4 RNA bases. This would be starting point of life as symbiosis of ordinary matter and dark matter as large $h_{eff}/h = n$ phases of ordinary matter generated at quantum criticality induced by say extraterrestrial impacts. The TGD based model for cold fusion and the recent results about superdense phase of hydrogen identifiable in TGD framework as dark proton sequences giving rise to dark nuclear strings provides support for this picture.

There is however a problem: a reductive environment (with ability to donate electrons) is needed in these experiments: it seems that early atmosphere was not reductive. In TGD framework one can imagine two - not mutually exclusive - solutions of the

problem. Either life evolved in underground oceans, where oxygen concentration was small or Pollack effect gave rise to negatively charged and thus reductive exclusion zones (EZs) as protons were transferred to dark protons at magnetic flux tubes. The function of UV radiation, catalytic action, and of shock waves would be generation of quantum criticality inducing the creation of EZs making possible dark $h_{eff}/h = n$ phases.

5.0.1 The first step: binding of dark protons to formamido-pyrimidine

I learned about very interesting discovery related to the problem of understanding how the basic building bricks of life might have emerged. RNA (DNA) has nucleotides A,G,C,U (T) as basic building bricks.

The first deep question is how the nucleotides A,G,C,U, and T emerged.

i. There are two types of nucleotides. Pyrimidines C and T/U (see `http://tinyurl.com/k3vxl9b`) have single carbon 6-cycle. Purines A and G (see `http://tinyurl.com/odvqw2p`) in turn have single 6-single and 5-cycle fused attached together along one side. Purines are clearly more complex than pyrimidines.

ii. U.K. chemist John Sutherland demonstrated a plausible sequence of steps leading to the emergence of pyrimidines. Purines turned out to be more problematic. Leslie Orgel and colleagues suggested a possible pathway but it produces purines in too tiny amounts.

Now a group led by Thomas Carell in Ludwig Maximilian University have found a more plausible mechanism [I4] (see `http://tinyurl.com/z65kpyo`).

i. Carell and colleagues studied the interaction of biomolecule formamido-pyrimidine (FaPy) with DNA and found that it also reacts to produce purines. Could FaPys have served as predecessors of purines? (For formamide see `http://preview.tinyurl.com/lwqyqnu` and for the class of chemical compounds known as amines see `http://tinyurl.com/mad6c2u`).

ii. The first step would have been a copious production of amino-pyrimidines containing several chemical groups known as amines. The problem is that the are so many amines and they normally react indiscriminantly to produce many different compounds. One wants mostly purines so that only one critical amine is wanted.

iii. When Carell and his team added some acid to the solution to decrease its pH, a miracle happened. The extra protons from acid attached to the amines of the amino-pyrimidine and made them non-reactive. There was however one exception: just the amine giving rise to purine in its reactions! The reactive amine also readily bonded with formic acid acid (see `http://tinyurl.com/lmstt7n`) or formamide. Hence it seems that one big problem has been solved.

The second challenge is to understand how the building bricks of RNA and DNA combined to form longer polymers and began to replicate.

i. One prevailing vision is that so called RNA world preceded the recent biology dominated by DNA. The goal has been to achieve generation of RNA sequence in laboratory. Unlike DNA RNA sequences are not stable and long sequences are difficult to generate. DNA in turn replicates only inside cell and the presence of what is known as ordered water seems to be essential for this.

ii. This step might involve new physics and chemistry and I have considered the possibility that the new physics involves magnetic bodies and dark proton sequences as a representation of the genetic code at the level of dark nuclear physics. There is no need to add that the fact that dark proton states provide representations for RNA, DNA, tRNA, and amino-acids [K5, K24] looks like a miracle and I find still difficult to believe that it is true and for genetic code. Also the representation of vertebrate code emerges in terms of correspondences of dark proton states.
This suggests that the replication of DNA and takes place at the level of dark proton sequencies - dark nuclear strings - serving as a dynamical template for the biological replication. Also transcription and translation would be induced by dark

process. Actually all biochemical processes could have as template the dynamics of molecular magnetic bodies and biochemistry would be kind of shadow of deeper dynamics.

iii. There is actually support for dark proton sequences. Quite recently I learned about the article of Leif Holmlid and Bernhard Kotzias [L11] (see `http://tinyurl.com/hxbvfc7`) about the superdense phase of hydrogen. In TGD superdense phase has interpretation as dark proton sequences at magnetic flux tubes with the Compton length of dark proton coded by $h_{eff}/h \simeq 2^{11}$ to electron's Compton length [L3]. Remarkably, it is reported that the superdense hydrogen is super-conductor and super-fluid at room temperatures and even above: this is just what TGD predicts. The dark protons in TGD inspired quantum biology [L6] should have much longer Compton length of order of the distance between nucleotides in DNA sequences in order to serve as templates for chemical DNA. This gives a dark Compton length of order $\simeq 3.3$ Angstroms from the fact that there are 10 codons per 10 nm. This gives $h_{eff}/h \simeq 2^{18}$.

One can return back to the first step in the genesis of DNA and RNA. The addition of protons to the solution used to model prebiotic environment to make it slightly acidic was the key step. Why?

i. Here cold fusion might help. Cold fusion is claimed to take place in electrolysis involving ionization and charge separation. The electric fields used in electrolysis induce ionization and thus charge separation. For me it has however remained a mystery how electric fields, which are extremely tiny using the typical strength of molecular electric field as standard are able to induce a charge separation. Of course, every chemist worth of his salt regards this as totally trivial problem. I am however foolish enough to consider the possibility that some new physics might be involved.

ii. The mechanism causing charge separation could be analogous to or that discovered by Pollack as he irradiated water bounded by a gel phase [L2] [L2]: in the recent case the electric field would take the role of irradiation as a feeder of energy. Negatively charged exclusion zones (EZs) were formed and 1/4 of protons went somewhere.
The TGD proposal is that part of protons went to magnetic flux tubes and formed dark proton sequences identifiable as dark nuclear strings. The scaled down nuclear binding energy favours the formation of dark nuclear strings perhaps proceeding as analog of nuclear chain reaction. This picture allows to ask whether dark proton sequences giving rise to a fundamental representation of the genetic code could have been present already in water [L6]!

iii. How DNA/RNA could have then formed? Could the protons making the solution acidic be dark so that the proton attaching to the amine would be dark? Could it be that for all amines except the right one the proton transforms to ordinary proton and destroys the chemical reactivity. Could the attached dark proton remain dark just for the correct amine so that the amine would remain reactive and give rise to purine in further reactions? Could A,G,C,T and U be those purines and pyrimidines - or even more general biomolecules - for which the attachment to dark proton does not transform it to ordinary proton and in this manner affect dramatically the chemical properties of the molecule? What is the condition for the preservation of the darkness of the proton?

5.0.2 Second step: Could shock waves due to extraterrestrial impacts have produced RNA bases?

About year later I learned about a further interesting finding related to the prebiotic evolution (see the popular article at `http://tinyurl.com/m8npeor`). The conclusion of the research article (see [I8]) is that that the extraterrestrial impacts on Earth's early atmosphere might have generated all 4 RNA bases (see `http://tinyurl.com/kxxc7db`). Also now the formamide is involved and my layman guess is that the motivation for this

comes from the experiment of Carell et al [I4] (see http://tinyurl.com/z65kpyo) discussed above. If formamide is generated then it becomes possible to generate formamido-pyridine and from this the RNA bases can be generated.

The experiment was a modern version of Urey-Miller experiment originally intended to simulate the situation at the surface of the early atmosphere modelled as a mixture a water H_2O, carbon-monoxide CO, and ammonium NH_3. The shock waves generated by the impacts were modelled in the experiment using terawatt laser pulses.

In the original Urey-Miller experiment amino-acids were generated. In the modern version of the experiment it was found that also formamide $CONH_3$ is formed, whose presence under suitable circumstances can lead to the generation of all 4 RNA bases. The presence of UV radiation, shock waves caused by extraterrestrial collisions, or of catalyst is the necessary condition.

In TGD Universe the additional condition could guarantee quantum criticality accompanied by dark $h_{eff}/h = n$ phases leading to the generation of dark protons and their stable binding with formamido-pyrimidine. The stable binding would not be possible for other amido-pyrimidines since dark protons would transform to ordinar protons for them. All 4 RNA bases would emerge from formamido-pyrimidine. All basic molecules of life could be produced in the reductive atmosphere.

The atmosphere was assumed to be reductive and this is a problem: the best that one can hope is that the early atmosphere was weakly reductive. Chemical compound is reductive (see http://tinyurl.com/m9cqnob) if it tends to donate electron. Reduction means receiving electron - and in chemistry hydrogen atom. To obtain a reducing atmosphere (see http://tinyurl.com/lx4tat2) one should remove oxygen from it. It however seems that the early atmosphere has contained oxygen and was oxidative rather than reductive. How could one overcome the problem?

i. In the experiment of Carell et al protons were added to reduce the pH of water. The basic experimental rule is that this makes the environment more reductive. The TGD proposal is that it led to a formation of dark proton-amine pair for the amine leading to the formation of purine. Charge separation by Pollack effect [L2] [L6] leading to the generation of dark proton sequences (dark nuclei) at magnetic flux tubes could have been due to the IR radiation, and maybe also by UV radiation, catalytic action, or by shock waves. The presence of electrons in the exclusion zones (EZs) could have made them electron donors and therefore reductive.
   The addition of protons in the experiment of Carell reducing the pH of water could have induced a transformation of dark protons at magnetic flux tube to ordinary protons. Dark protons bound to the amines would have transformed to ordinary protons and inducing their chemical inactivity. Only for the amine formamide serving as a precursor of purine the dark proton-amine bound state was stable and remained chemically reactive since dark proton did not affect the properties of visible matter part of the compound. Symbiosis between dark and ordinary matter began. This view conforms also with the vision about the pairing of DNA/RNA and dark DNA/RNA formed by sequences of proton triplets representing DNA/RNA codons [L7]. DNA is indeed negatively charged and dark proton could neutralize it but allow it to remain chemically active.

ii. Second possibility is suggested by the conjecture that prebiotic life evolved in the crust of Earth, perhaps in the underground oceans or regions related to volcanoes [K4, L6]. The content of oxygen of this environment could have been much lower than at the surface making it reductive: it would not be possible to even talk about atmosphere. But where did the metabolic energy come from? Could volcanic energy emitted as dark long wave photons with energies in the range of bio-photon energies help here? There are indeed a theories assuming that first life forms emerged from volcanoes. These problems are discussed in [K4, L6] from TGD viewpoint. Note that these two explanations do not exclude each other.

5.1 Could the replication of mirror DNA teach something about chiral selection?

I received a link to a very interesting popular article (see http://tinyurl.com/zqgutdv) from which I learned that short strands of mirror DNA and mirror RNA - known as aptamers - have been be produced commercially for decades - a total surprise to me. Aptamers bind to targets like proteins and block their activity and this ability can be utilized for medical purposes.

Now researchers at Tsinghua University of Beijing have been able to create a mirror variant of an enzyme - DNA polymeraze - catalyzing the transcription of mirror DNA to mirror RNA also replication of mirror DNA [I12]. What is needed are the DNA strand to be replicated or transcribed, the mirror DNA nucleotides, and short primer strand (see http://tinyurl.com/j3o8cyx)) since the DNA polymeraze starts to work only if the primer is present. This is like recalling a poem only after hearing the first few words.

The commonly used DNA polymerase containing about 600 amino-adics is too long to be built up as a right-handed version and researchers used a much shorter version: African swine fever virus having only 174 amino-acids. The replication turned out to be very slow. A primer of 12 nucleotides was extended to a strand of 18 nucleotides in about 4 hours: 3/2 nucleotides per hour. The extension to a strand of 56 nucleotides took 36 hours making 44/36= 11/9 nucleotides per hour. DNA and its mirror image co-existed peacefully in a solution. One explanation for the absence of mirror life is that the replication and transcription of mirror form was so slow that it lost the fight for survival. Second explanation is that the emergence of mirror forms of DNA polymerase and other enzymes was less probable.

Can one learn anything about this?

i. Chiral selection is one of the deep mysteries of biology. Amino-acids are left-handed and DNA and RNA double strands form a right-handed screw. One can assign handedness with individual DNA nucleotides and with DNA double strand but web sources speak only about the chirality of double strand. If the chirality of the DNA nucleotides were not fixed, it would have been very probably discovered long time ago as an additional bit doubling the number of DNA letters.

ii. What could be the origin of the chirality selection? Second helicity could have been loser in the fight for survival and the above finding supports this: fast ones eat the slow ones like in market economy. There must be however a breaking of mirror symmetry. Weak interactions break of mirror symmetry but the breaking is extremely small because the weak bosons mediating weak interaction are so massive that the length scale in which the breaking of mirror symmetry matters is of order 1/100 times proton size. This breaking is quite too small to explain chiral selection occurring in nano-scales: there is discrepancy of 8 orders of magnitude. The proposal has been that the breaking of mirror symmetry has been spontaneous and induced by a very small seed. As far as I know, no convincing candidate for the seed has been identified.

According to TGD inspired model chiral selection would be induced from that in dark matter sector identified in terms of phases of ordinary matter with non-standard value of Planck constant $h_{eff}/h = n$ [K19, K26]. In living matter dark matter would reside at magnetic flux tubes and control ordinary matter. TGD predicts standard model couplings, in particular weak parity breaking. For $h_{eff}/h = n$ the scale below which weak bosons behave as massless particles implying large parity breaking is scaled up by n. Large parity breaking for dark matter becomes possible in even biological length scales for large enough h_{eff}.

The crucial finding is that the states of dark proton regarded as part of dark nuclear string can be mapped naturally to DNA, RNA, tRNA, and amino-acid molecules and that vertebrate genetic code can be reproduced naturally [K5]. This suggests that genetic code is realized at the level of dark nuclear physics and induces its chemical variant. More generally, biochemistry would be kind of shadow of dark matter physics.

A model for dark proton sequences and their helical pairing is proposed and estimates for the parity conserving and breaking parts of Z^0 interaction potential are deduced.

5.1.1 Dark matter and chirality selection

In TGD framework the hierarchy of Planck constants suggests an explanation for the chirality selection.

i. In TGD Universe the new physics of quantum biology involves magnetic bodies and dark proton sequences as a representation of the genetic code at the level of dark nuclear physics. The crucial observation is that dark proton states provide representations for RNA, DNA, tRNA, and amino-acids [K5, K24] and there is also natural map between DNA and amino-acid type states giving rise to vertebrate genetic code. This looks like a miracle and I find still difficult to believe that it is true. A The extreme slowness of the wrong-handed DNA replication as compared to the ordinary replication means large breaking of parity symmetry. This is possible to understand in terms of weak interactions only if they are dark in DNA length scales so that weak bosons are effectively massless and weak interactions are as strong as electromagnetic interactions.
   This suggests that the replication of DNA and takes place at the level of dark proton sequencies - dark nuclear strings - serving as a dynamical template for the biological replication. Also transcription and translation would be induced by dark processes. Actually all biochemical processes could have as template the dynamics of molecular magnetic bodies and biochemistry would be kind of shadow of dark matter physics.
   If this is the case, then chiral selection would take place the selection at the level of dark nuclear strings and induce that the level of biochemistry. If dark and ordinary chiralities fit together like hand and glove. Dark matter at magnetic bodies could control the behavior of ordinary matter. By parity breaking the dark weak binding energy between members of proton pairs in the dark DNA strand consisting of a pair of helical dark proton strings is higher for the second helical chirality and would favour this chirality. A very naïve thermodynamical estimate is that the ratio of the densities of two chiralities is proportional to the Boltzmann exponent $exp(-\Delta E_B/T)$. The transition to thermodynamical equilibrium can be however very slow so that thermodynamical argument need not make sense.

ii. There is experimental support for dark proton sequences. Leif Holmlid and Berhard Kotzias [L11] (see `http://tinyurl.com/hxbvfc7`) have published an article about the superdense phase of hydrogen proposed to make possible to overcome the Coulomb wall making cold fusion impossible in the textbook Universe. In TGD superdense phase has interpretation as dark proton sequences at magnetic flux tubes with the Compton length of dark proton coded by $h_{eff}/h = n_{eff} \simeq 2^{11}$ to electron's Compton length [L3]. Remarkably, it is reported that the superdense hydrogen is super-conductor and super-fluid at room temperatures and even above: this is just what TGD predicts.
   The dark protons in TGD inspired quantum biology (see `http://tinyurl.com/lwxdl7y`) should have much longer Compton length of the order of the distance between nucleotides in DNA sequences in order to serve as templates for chemical DNA. This gives a dark Compton length of order $\simeq 3.3$ Angstroms from the fact that there are 10 codons per 10 nm. This would give $n_{eff,p} \simeq 2^{18}$. The safest manner to estimate the dark binding energy is by scaling the binding energy about $E_B \simeq 7$ MeV per nucleon by $1/n_{eff,p}$ to give $E_{B,d} = E_B/n_{eff,p} = 28$ eV.

iii. Further evidence for the importance of dark protons in biology comes from the recent finding of the group led by Thomas Carell related to the understanding the origins of life [I4] (see `http://tinyurl.com/z65kpyo`). For TGD inspired model see [L10], [K21]. Carell et al have identified a mechanism leading to the generation of purines A and G, which besides pyrimidines A,T (U) are the basic building bricks of DNA and RNA. The crucial step is to make the solution involved slightly acidic

by adding protons.
In TGD inspired quantum biology this suggest that the protons in the acidic water are dark and that the attachment of the dark protons to the amines of the amino-pyrimidine transforms them to ordinary protons and makes the amino-pyrimidine non-reactive. There would be however one exception: the amine which reacts further to give purines as a reaction product. In this case the proton would remain dark and the chemical properties of the amine would remain intact. This suggests that DNA nucleotides and DNA strands can attach to dark protons or are accompanied by them.

5.1.2 Model for the replication of DNA

One can consider a detailed model for the replication as induced by the addition of dark protons to dark proton sequence representing dark DNA strand. The added dark protons would be accompanied or attached with the DNA nucleotides as suggested by the work of Carell et al.

i. In the replication and transcription of DNA the basic step would be the addition of dark proton to an increasing dark proton sequence. The need for primer means that there must already exist a dark proton sequence. In the presence of prime the attractive dark nuclear binding energy of the added dark proton with the prime would make the dark fusion rate higher. The addition of dark protons could proceed like a dark nuclear chain reaction. It would be made possible by the dark nuclear binding energy per proton scaling like $1/h_{eff,p}$.
For the ordinary nuclei the binding energy per nucleon would be of the order of 7 MeV (note that charge independence of strong interactions holds in good approximation). The scaling down by $h_{eff}/h = 2^{18}$ would give $E_B \simeq 4$ eV, which corresponds to UV photon energy. Note that bio-photons assumed to correspond dark photons with same energy have energies in visible and UV range.

ii. Dark nuclear energy cannot explain parity breaking. The axial part of dark weak energy between dark protons belonging to dark strand and its conjugate and having nuclei acids and its conjugate as a chemical "shadow" must be also involved. Two values of h_{eff} are involved: $h_{eff,p}$ assignable to the flux tubes containing dark protons parallel to DNA strands and $h_{eff,W}$ assignable to the transversal flux tube connecting dark protons associated with different dark strands.
One of the assumptions of the TGD inspired model of cold fusion [L3, L11] is that the weak scale is scaled up from weak boson Compton length to about atomic length scale. This would require $h_{eff,W}/h = n_{eff,W}$ for weak bosons to be roughly

$$n_{eff,W} \simeq \frac{m_Z}{m_p} \times n_{eff,p} \simeq 91 \times n_{eff,p}$$

so that one would have $n_{eff,W} \simeq 2^{25}$. If this is the case weak interactions are of essentially same strength as em interaction below the scaled up Compton scale of order 3 Angstroms. This makes it possible to talk about classical Z^0 Coulomb potential and about spin dependent parity breaking Z^0 force. These two interaction energies sum up and this reduces the binding energy per proton in double strand for the other chirality.

iii. The parity conserving Z^0 Coulomb interaction energy between two protons at different strands connected by a flux tube is given by the expression

$$\begin{aligned} &V_{PC}(r_{12}) = -kV(r_{12}) \ , \quad V(r_{12}) = \tfrac{\hbar}{r_{12}} \ , \\ &k = \alpha_Z Q_Z^2(p) \ , \qquad\qquad \alpha_Z = \tfrac{\alpha}{sin^2(\theta_W)cos^2(\theta_W)} \ , \quad Q_Z(p) = 1/4 - sin^2(\theta_W) \ . \end{aligned} \tag{5.1}$$

Here units $\hbar = 1$, $c = 1$ are used. r_{12} refers to the distance between dark protons at magnetic flux tubes assignable to DNA strands. Base pair thickness is about .34

nm and thickness of DNA double strand is about 2 nm. r_{12} could be between these two limits.

iv. The spin dependent and parity non-conserving Z^0 interaction potential for Dirac spinors proportional to the gradient of the Z^0 Coulomb potential can be written as

$$V_{PNC} = \alpha_Z Q_Z^A(p) Q_Z^V(p) \gamma_5 V(r_{12}) \ . \tag{5.2}$$

Here $Q_Z^A = I_{3,A}/2 = 1/4$ is the axial weak charge of proton. The vectorial charge of proton is $Q_Z(p) = 1/4 - sin^2(\theta_W) \simeq 0.02$ so that it is much smaller than $Q_Z^A(p)$. Hence the axial force dominates by a factor $10^2/8 \sim 12.5$ for a given relative position. Usually the axial part becomes very small by symmetries as one estimates quantum averages but in the recent situation one cannot expect this since the positions of dark protons are in the first approximation fixed.

v. Using non-relativistic correspondence following from $\gamma_5 = \gamma_0\gamma_1\gamma_2\gamma_3$ and $(\gamma_5)^2 = -1$: this equation holds true also for $(\gamma^0\gamma^k p_k(m)$, and one has

$$\gamma_5 \to \frac{\overline{\sigma} \cdot p}{m_p} \ .$$

Here $\overline{\sigma}$ denotes Pauli sigma matrices expressible as $\gamma^0\gamma^i$). Using the replacement $p \leftrightarrow i\hbar_{eff,W}\nabla$ one can write V_{PNC} as the sum of the axial energies of the two protons

$$\begin{aligned} V_{s_1,s_2} &= V_{s_1} + V_{s_2} \ , \\ V_{s_i} &= \frac{\hbar_{eff,W}}{m_p}\overline{\sigma}_i \cdot \nabla_i V_{PC}(r_{12}) = (-1)^i \frac{k n_{eff,W}\hbar}{m_p}\hbar\frac{\overline{\sigma}_i \cdot \overline{r}_{12}}{r_{12}^2} \ . \ i = 1,2 \ . \end{aligned} \tag{5.3}$$

The parity breaking part of Z^0 force is proportional to $n_{eff,W}$ from the expression of momentum operator in terms of gradient operator so that dark matter physics makes itself visible and increases further the magnitude of parity breaking. The potential energy changes sign in reflection $\overline{r}_{12} \to -\overline{r}_{12}$. This gives

$$\begin{aligned} V_{s_1,s_2} &= -\frac{\alpha_Z}{4}(\frac{1}{4} - sin^2(\theta_W))\frac{n_{eff,W}\hbar}{m_p r_{12}}\frac{(\overline{\sigma}_1 - \overline{\sigma}_2)\cdot\overline{r}_{12}}{r_{12}}\frac{\hbar}{r_{12}} \\ &= \frac{1}{4}\frac{1}{(\frac{1}{4} - sin^2(\theta_W)}\frac{n_{eff,W}\hbar}{m_p r_{12}}\frac{(\overline{\sigma}_1 - \overline{\sigma}_2)\cdot\overline{r}_{12}}{r_{12}}V_{PC}(r_{12}) \ . \end{aligned} \tag{5.4}$$

vi. For the vectorial part one has

$$V_{PC} = -\alpha_Z(\frac{1}{4} - sin^2(\theta_W))^2 V(r_{12}) \ . \tag{5.5}$$

The order of magnitude is about $V_Z = .16/x$ eV.

vii. The condition that r_{12} corresponds to dark Compton length of proton implies in the first approximation $\frac{n_{eff,p}}{m_p r_{12}} = 1$ so that $n_{eff,W}$ proportionality gives factor $m_Z/m_p \simeq 91$. The order of magnitude parity breaking potential is the value potential at distance in the range $r_{12} \in [3.4, 2]$ nm. Let us expres the horizontal distance between the paired dark protons as $r_{12} = x$ Angstroms. This gives for the axial part

$$\begin{aligned} V_{s_1,s_2} &= \frac{1}{4}\frac{1}{(\frac{1}{4}-sin^2(\theta_W)}\frac{m_Z}{m_p}(\overline{\sigma}_1-\overline{\sigma}_2)\cdot\frac{\overline{r}_{12}}{r_{12}}V_{PC}(r_{12}) \\ &\simeq .5\times 10^2\times 91\times\frac{V_{PC}(r_{12})}{x}\times(\overline{\sigma}_1-\overline{\sigma}_2)\cdot\frac{\overline{r}_{12}}{r_{12}} \ . \end{aligned} \tag{5.6}$$

The order or magnitude for the axial part is roughly $4550/x$ times larger than for the vectorial part. V_{PNC} is proportional to $1/x^2$ and V_{PC} to $1/x$. The condition that the states are spin eigenstates requires that spin quantization axes must be chosen along the flux tube connecting the dark protons. This is rather natural choice.

This would give for the axial part order of magnitude $V_{PNC}\sim 728/x^2$. For 2 nm distance one would obtain $V_{PNC}\sim 1.82$ eV. For 1 nm distance one would have $x=10$ and this would give $V_{PNC}\simeq 7.28$ eV. For this value $V_{PC}\simeq 16$ meV, which is of same order of magnitude as thermal energy $kT/2$ at room temperature.

viii. The process of adding dark protons to the increasing DNA sequence must be possible irrespectively of the direction of spin. The spin eigenvalue in the direction of the horizontal axis connecting the members of dark proton pair is assumed to be opposite for the members of the dark proton pairs of dark double strand. This assumption comes from the model of the dark genetic code. This demands that V_{NPC} is considerably smaller than strong binding energy E_B. For 1 nm distance one has $V_{PNC}\simeq 7.28$ eV considerably smaller than $E_B\simeq 28$ eV.

ix. What is the relation of the fermionic chirality to the geometric chirality? The reflection for dark protons induces the reflection of the entire helix turning also its direction. The reflection permutes the dark protons of each pair since their positions are related by reflection in the plane orthogonal to z-axis $(x_2,y_2)=(-x_1,-y_1)$. One has $(x_1,y_1,z)\leftrightarrow(x_2,y_2,-z)$. A further rotation of π in say (x,z)-plane around say y-axis is symmetry and gives $(x_2,y_2,-z)\rightarrow(-x_2,y_2,z)=(x_1,-y_1,z)$. Hence the net effect is $(x_1,y_1,z)\rightarrow(x_1,-y_1,z)$ and DNA strand with an opposite screw direction is generated.

The model of dark genetic code motivates the assumption that the dark protons of the pair are spin eigenstates for the spin projection along the axis connecting the members of the pair. The direction of the spin quantization axis changes in reflection from that given by (x_1,y_1) to that given by $(x_1,-y_1)$ so that the states are not anymore eigenstates of the spin projection along this axis. Thus the fermionic chirality indeed correlates with the chirality of double strand and the two chiralities are in physically different position.

What happens at the level of classical fields? Kähler magnetic field transforms like angular momentum in reflections and rotations as is easy to see from its expression in terms of vector potential. Hence it does not change its direction in reflection but changes its direction in the rotation. Hence the magnetic flux along flux tube changes to opposite in the reflection. This also affects the physics and induces effects at the level of dark strong interactions. The magnetic energy is of form $s\cdot B$ and vanishes classically. Quantum mechanically it does not vanish since s is operator and one can wonder what this implies physically.

5.1.3 Differences between standard model and TGD based description

The above estimate relies on standard model, which is quantum field theory in Minkowski space, and one can wonder what new elements TGD brings in. I do not try to estimate the effects in TGD framework but just list the differences.

i. In TGD framework space-time is 4-surface in $M^4\times CP_2$ and this description must be replaced with a description using 8-D imbedding spinors. At space-time level massive M^4 Dirac equation $p_k\gamma^k\Psi=m\Psi$ is replaced by 8-D chiral symmetry implying separate conservation of quark and lepton numbers with the analog of massless

Dirac equation for the Kähler-Dirac gamma matrices, which are superpositions of M^4 and CP_2 gamma matrices. K-D gamma matrices are contractions of canonical momentum current densities of Kähler action with the imbedding space gamma matrices. If the action is volume term, one obtains induced gamma matrices. The twistorialization of TGD by replacing the imbedding space with the product of twistor spaces of M^4 and CP_2 and lifting space-time surfaces to their twistor spaces with induced twistor structure leads to the addition of volume term to Kähler action [K22]. This term corresponds to cosmological constant and is extremely small in the recent cosmology.

ii. One can decompose K-D gamma matrices to their M^4 and CP_2 parts: $\Gamma^\alpha = \Gamma^\alpha_{M^4} + \Gamma^\alpha_{CP_2}$ and write the K-D equation as $\Gamma^\alpha_{M^4} D_\alpha \Psi = -\Gamma^\alpha_{CP_2}\Psi$. The presence of $\Gamma^\alpha_{CP_2}$ parts breaks conservation of M^4 chirality and serves as a signal for massivation. This operator is kind of mass operator acting non-trivial in electroweak spin degrees of freedom assignable to CP_2 and the action of its square is analogous to the action of mass squared operator.
The understanding of particle massivation at this level does not seem however possible and the proper approach relies of p-adic thermodynamics for super-Virasoro representations for which ground states are characterized by the modes of imbedding space spinors which are massless in 8-D sense and are eigenstates of M^4 mass squared operator with eigenvalues determined by CP_2 spinor Laplacian [K7]. Its action on M^4 chirality is same as action of mass in massive Dirac equation in M^4.

iii. In the case of M^4 Dirac equation the multiplication of massive Dirac equation with γ_5 using anti-commutativity of γ_5 and γ_k gives $\gamma^k p_k \gamma_5 \Psi = -m\gamma_5\Psi$ instead of$p_k\gamma^k\Psi = m\Psi$. TGD framework γ_5 anti-commutes with $\Gamma^\alpha_{M^4}$ but commutes with $\Gamma^\alpha_{CP_2}$ so that also now one has similar equation $\Gamma^\alpha_{M^4} D_\alpha \Psi = +\Gamma^\alpha_{CP_2}\Psi$.

5.2 Is dark DNA dark also in TGD sense?

I encountered a highly interesting article about "dark DNA" hitherto found in the genome of gerbils and birds, for instance in the genome of of the sand rat living in deserts (see `http://tinyurl.com/y8zdgnej`). The gene called Pdxl related to the production of insulin seems to be missing as also 87 other genes surrounding it! What makes this so strange that the animal cannot survive without these genes! Products that the instructions from the missing genes would create are however detected!

According to the ordinary genetic, these genes cannot be missing but should be hidden, hence the attribute "dark" in analogy with dark matter. The dark genes contain A lot of G and C molecules and this kind of genes are not easy to detect: this might explain why the genes remain undetected.

A further interesting observation is that one part of the sand rat genome has many more mutations than found in other rodent genomes and is also GC rich. Could the mutated genes do the job of the original genes? Missing DNA are found in birds too. For instance, the gene for leptin - a hormone regulating energy balance - seems to be missing.

The finding is extremely interesting from TGD view point, where dark DNA has very concrete meaning. Dark matter at magnetic flux tubes is what makes matter living in TGD Universe. Dark variants of particles have non-standard value $h_{eff} = n \times h$ of Planck constant making possible macroscopic quantum coherence among other things. Dark matter would serve as template for ordinary matter in living systems and biochemistry could be kind of shadow of the dynamics of dark matter. What I call dark DNA would correspond to dark analogs of atomic nuclei realized as dark proton sequences with entangled proton triplet representing DNA codon. The model predicts correctly the numbers of DNA codons coding for given amino-acid in the case of vertebrate genetic code and therefore I am forced to take it very seriously [L7, L4] (see `http://tinyurl.com/jgfjlbe` and `http://tinyurl.com/ydb2tfy8`).

The chemical DNA strands would be attached to parallel dark DNA strands and the chemical representation would not be always perfect: this could explain variations of

DNA. This picture inspires also the proposal that evolution is not a passive process occurring via random mutations with survivors selected by the evolutionary pressures. Rather, living system would have R&D lab as one particular department. Various variants of DNA would be tested by transcribing dark DNA to ordinary mRNA in turn translated to amino-acids to see whether the outcome survives. This experimentaiton might be possible in much shorted time scale than that based on random mutations. Also immune system, which is rapidly changing, could involve this kind of R&D lab.

Also dark mRNA and amino-acids could be present but dark DNA is the fundamental information carrying unit and it would be natural to transcribe it to ordinary mRNA. Of course, also dark mRNA could be produced and translated to amino-acids and even dark amino-acids could be transformed to ordinary ones. This would however require additional machinery.

What is remarkable is that the missing DNA is indeed associated with DNA sequences with exceptionally high mutation rate. Maybe R&D lab is there! If so, the dark DNA would be dark also in TGD sense! Why GC richness should relate to this, is an interesting question.

5.3 Clustering of RNA polymerase molecules and Comorosan effect

Once again I had good luck: I received a link (see `http://tinyurl.com/y7bego83`) to a highly interesting popular article telling about the work by Ibrahim Cisse at MIT and his colleagues [I6] (see `http://tinyurl.com/y9wzt5yl`) about the clustering of RNA polymerase proteins in the transcription of RNA. Similar clustering has been observed already earlier and interpreted as a phase separation giving rise to protein droplets [L26]. Now this interpretation is not proposed by experiments but they say that it is quite possible but they cannot prove it.

I have already earlier discussed the coalescence of proteins into droplets as this kind of process in TGD framework [K19] [L26]. The basic TGD based ideas is that proteins - and biomolecules in general - are connected by flux tubes characterized by the value of Planck constant $h_{eff} = n \times h_0$ for the dark particles at the flux tube. The higher the value of n is the larger the energy of given state. For instance, the binding energies of atoms decrease like $1/n^2$. Therefore the formation of the molecular cluster liberates energy usable as metabolic energy.

Remark: h_0 is the minimal value of h_{eff}. The best guess is that ordinary Planck constant equals to $h = 6h_0$ [L9, L24] (see `http://tinyurl.com/goruuzm` and `http://tinyurl.com/y9jxyjns`.

5.3.1 TGD view about the findings

Gene control switches - such as RNA II polymerases in DNA transcription to RNA - are found to form clusters called super-enhancers. Also so called Mediator proteins form clusters. In both cases the number of members is in the range 200-400. The clusters are stable but individual molecules spend very brief time in them. Clusters have average lifetime of $5.1 \pm .4$ seconds.

Why the clustering should take place? Why large number of these proteins are present although single one would be enough in the standard picture. In TGD framework one can imagine several explanations. One can imagine at least following reasons.

i. If the initiation of transcription is quantum process involving state function reduction, clustering could allow to make this process process deterministic at the level of single gene in spite of the non-determinism of state function reduction. Suppose that the initiation of transcription is one particular outcome of state function reduction. If there is only single RNA II polymerase able to make only single trial, the changes to initiate the transcription are low. This could be the case if the protein provides metabolic energy to initiate the process and becomes too "tired" to try

again immediately. In nerve pulse transmission there is analogous situation: after the passing of the nerve pulse generation the neuron has dead time period. As a matter of fact, it turns out that the analogy could be much deeper.
How to achieve the initiation with certainty in this kind of situation? Suppose that the other outcomes do not affect the situation appreciably. If one particular RNA polymerase fails to initiate it, the others can try. If the number of RNA transcriptase molecule is large enough, the transcription is bound to begin eventually! This is much like in fairy tales about princess and suitors trying to kill the dragon to get the hand of princess. Eventually comes the penniless swineherd.

ii. If the initiation of transcription requires large amount of metabolic energy then only some minimal number of N of RNA II polymerase molecules might be able to provide it collectively. The collective formed by N molecules could correspond to a formation of magnetic body (MB) with a large value of $h_{eff} = n \times h_0$ and controlling the molecules and inducing its coherent behavior. The molecules would be connected by magnetic flux tubes.

iii. If the rate for occurrence is determined by an amplitude which is superposition of amplitudes assignable to individual proteins the rate is proportional to N^2, N the number of RNA II polymerase molecules. The process for the cluster is reported to be surprisingly fast as compared to the expectations - something like 20 seconds. The earlier studies have suggests that single RNA polymerase stays at the DNA for minutes to hours.
Clustering could allow to speed up bio-catalysis besides the mechanism allowing to find molecules to find by a reduction of $h_{eff}/h = n$ for the bonds connecting the reactants and the associated liberation of metabolic energy allowing to kick the reactants over the potential wall hindering the reaction.

Concerning the process of clustering there are two alternative options both relying on the model of liquid phase explaining Maxwell's rule assuming the presence of flux tube bonds in liquid and of water explaining its numerous anomalies in terms of flux tubes which can be also dark (see `http://tinyurl.com/ydhknc2c`).

i. **Option I**: Molecules could form in the initial situation a phase analogous to vapour phase and there would be very few flux tube bonds between them. The phase transition would create liquid phase as flux tube loops assignable to molecules would reconnect form flux tube pairs connecting the molecules to a tensor network giving rise to quantum liquid phase. The larger then value of n, the longer the bonds between molecules would be. This kind of model [L17] (see `http://tinyurl.com/yassnhzb`) is used to explain the strange findings that a system consisting of plastic balls seems to show primitive features of life such as metabolism.

ii. **Option II**: The molecules are in the initial state connected by flux tubes and form a kind of liquid phase and the clustering reduces the value of $h_{eff}/h = n$ and therefore the lengths of flux tubes. This would liberate dark energy as metabolic energy going to the initiation of the transcription. One could indeed argue that connectedness in the initial state with large enough value of n is necessary since the protein cluster must have high enough "IQ" to perform intelligent intentional actions.

Protein blobs are said to be drawn together by the "floppy" bits (pieces) of intrinsically disordered proteins. What could this mean in the proposed picture? Disorder would mean absence of correlations between building bricks of floppy parts of the proteins in translational degrees of freedom.

i. Could floppiness correspond to low string tension assignable to long flux loops with large n assignable to the building bricks of "floppy" pieces of protein? Could reconnection for these loops give rise to pairs of flux tubes connecting the proteins in the transition to liquid phase (Option I)? Floppiness would also make possible to scan the environment by flux loops to get in touch with the flux loops of other molecules and in the case of hit (cyclotron resonance) induce reconnection.

ii. In spite of floppiness in this sense, one could have quantum correlations between the internal quantum numbers of the building bricks of the floppy pieces. This would also increase the value of n serving as molecular IQ and provide molecule with higher metabolic energy liberated in the catalysis.

5.3.2 About Comorosan effect and clustering of RNA II polymerase proteins

What about the interpretation of the time scales τ equal 5, 10, and 20 seconds appearing in the clustering of RNA II polymerase proteins and Mediator proteins? What is intriguing that so called Comorosan effect [I11, I2] involves time scale of 5 seconds and its multiples claimed by Comorosan long time ago to be universal time scales in biology. The origin of these time scales has remained more or less a mystery although I have considered several TGD inspired explanations for this time scale is based on the notion of gravitational Planck constant [K13] (see `http://tinyurl.com/yb8fw3kq`).

One can consider several starting point ideas, which need not be mutually exclusive.

i. The time scales τ associated with RNA II polymerase and perhaps more general bio-catalytic systems as Comorosan's claims suggest could correspond to the durations of processes ending with "big" state function reduction. In zero energy ontology (ZEO) there are two kinds of state function reductions [L21]. "Small" state function reductions - analogs of weak measurements - leave the passive boundary of causal diamond (CD) unaffected and thus give rise to self as generalized Zeno effect. The states at the active boundary change by a sequence of unitary time evolutions followed by measurements inducing also time localization of the active boundary of CD but not affecting passive boundary. The size of CD increases and gives rise to flow of time defined as the temporal distance between the tips of CD. Large reductions change the roles of the passive and active boundaries and mean death of self. The process with duration of τ could correspond to a life-time of self assignable to CD.

   Remark: It is not quite clear whether CD can disappear and generated from vacuum. In principle this is possible and the generation of mental images as sub-selves and sub-CDs could correspond to this kind of process.

ii. In [K13] I proposed that Josephson junctions are formed between reacting molecules in bio-catalysis. These could correspond to the shortened flux tubes. The difference $E_J = ZeV$ of Coulomb energy of Cooper pair over flux tube defining Josephson junction between molecules would correspond to Josephson frequency $f_J = 2eV/h_{eff}$. If this frequency corresponds to $\tau_J = 5$ seconds, h_{eff} should be rather large since E_J is expected to be above thermal energy at physiological temperature.

   Could Josephson radiation serve as a kind of of synchronizing clock for the state function reductions so that its role would be analogous to that of EEG in case of brain? A more plausible option is that Josephson radiation is a reaction to the presence of cyclotron radiation generated at MB and performing control actions at the biological body (BB) defined in very general sense. In the case of brain dark cyclotron radiation would generate EEG rhythms responsible for control via genome and dark generalized Josephson radiation modulated by nerve pulse patterns would mediate sensory input to the MB at EEG frequencies.

   A good guess motivated by the proposed universality of the Comorosan periods is that the energy in question does not depend on the catalytic system and corresponds to Josephson energy for protein through cell membrane acting as Josephson junction and giving to ionic channel or pump. The flux tubes themselves have universal properties.

iii. The hypothesis $\hbar_{eff} = \hbar_{gr} = GMm/\beta_0 c$ of Nottale [**?**] for the value of gravitational Planck constant [K27, K25, K26, K19] gives large $\hbar$. Here $v_0 = \beta_0 c$ has dimensions of velocity. For dark cyclotron photons this gives large energy $E_c \propto \hbar_{gr}$ and for dark Josephson photons small frequency $f_J \propto 1/h_{gr}$. Josephson time scale τ_f would be proportional to the mass m of the charged particle and therefore to mass number A

of ion involved: $f_J \propto A$ possibly explaining the appearance of multiples of 5 second time scale. Cyclotron time scale does not depend on the mass of the charged particle at all and now sub-harmonics of τ_c are natural.

The time scales assignable to CD or the lifetime-time of self in question could correspond to either cyclotron of Josephson time scale τ.

i. If one requires that the multiplies of the time scale 5 seconds are possible, Josephson radiation is favoured since the Josephson time scale proportional to $h_{gr} \propto m \propto A$, A mass number of ion.
The problem is that the values $A = 2, 3, 4, 5$ are not plausible for ordinary nuclei in living matter. Dark nuclei at magnetic flux tubes consisting of dark proton sequences could however have arbitrary number of dark protons and if dark nuclei appear at flux tubes defining Josephson junctions, one would have the desired hierarchy.

ii. Although cyclotron frequencies do not have sub-harmonics naturally, MB could adapt to the situation by changing the thickness of its flux tubes and by flux conservation the magnetic field strength to which f_c is proportional to. This would allow MB to produce cyclotron radiation with the same frequency as Josephson radiation and MB and BB would be in resonant coupling.

Consider now the model quantitatively.

i. For $\hbar_{eff} = \hbar_{gr}$ one has

$$r = \frac{\hbar_{gr}}{\hbar} = \frac{GM_D m}{c\beta_0} = 4.5 \times 10^{14} \times \frac{m}{m_p}\frac{y}{\beta_0} \ .$$

Here $y = M_D/M_E$ gives the ratio of dark mass M_D to the Earth mass M_E. One can consider 2 favoured values for m corresponding to proton mass m_p and electron mass m_e.

ii. $E = h_{eff} f$ gives the concrete relationship $f = (E/eV) \times 2.4 \times 10^{14} \times (h/h_{eff})$ Hz between frequencies and energies. This gives

$$x = \frac{E}{eV} = 0.4 \times r \times \frac{f}{10^{14} Hz} \ .$$

iii. If the cyclotron frequency $f_c = 300$ Hz of proton for $B_{end} = .2$ Gauss corresponds to bio-photon energy of x eV, one obtains the condition

$$r = \frac{GM_D m_p}{\hbar\beta_0} \simeq .83 \times 10^{12} x \ .$$

Note that the cyclotron energy does not depend on the mass of the charged particle. One obtains for the relation between Josephson energy and Josephson frequency the condition

$$x = \frac{E_J}{eV} = 0.4 \times .83 \times 10^{-2} \times \frac{m}{m_p} \times x\frac{f_J}{Hz} \ , \ E_J = ZeV \ .$$

One should not confuse eV in ZeV with unit of energy. Note also that the value of Josephson energy does not depend on h_{eff} so that there is no actual mass dependence involved.

For proton one would give a hierarchy of time scales as A-multiples of $\tau(p)$ and is therefore more natural so that it is natural to consider this case first.

i. For $f_J = .2$ Hz corresponding to the Comorosan time scale of $\tau = 5$ seconds this would give $ZeV = .66x$ meV. This is above thermal energy $E_{th} = T = 27.5$ meV at $T = 25$ Celsius for $x > 42$. For *ordinary* photon ($h_{eff} = h$) proton cyclotron frequency $f_c(p)$ would correspond for $x > 42$ to EUV energy $E > 42$ eV and to wavelength of $\lambda < 31$ nm.
The energy scale of Josephson junctions formed by proteins through cell membrane of thickness $L(151) = 10$ nm is slightly above thermal energy, which suggests $x \simeq$

120 allowing to identify $L(151) = 10$ nm as the length scale of the flux tube portion connecting the reactants. This would give $E \simeq 120$ eV - the upper bound of EUV range. For $x = 120$ one would have $GM_E m_p y/v_0 \simeq 10^{14}$ requiring $\beta_0/y \simeq 2.2$. The earlier estimates [K19] for the mass M_D give $y \sim 2 \times 10^{-4}$ giving $\beta_0 \sim 4.4 \times 10^{-4}$. This is rather near to $\beta_0 = 2^{-11} \sim m_e/m_p$ obtained also in the model for the orbits of inner planets as Bohr orbits.

For ion with mass number A this would predict $\tau_A = A \times \tau_p = A \times 5$ seconds so that also multiples of the 5 second time scale would appear. These multiples were indeed found by Comoran and appear also in the case of RNA II polymerase.

ii. For proton one would thus have 2 biological extremes - EUV energy scale associated with cyclotron radiation and thermal energy scale assignable to Josephson radiation. Both would be assignable to dark photons with $h_{eff} = h_{gr}$ with very long wavelength. Dark and ordinary photons of both kind would be able to transform to each other meaning a coupling between very long lengths scales assignable to MB and short wavelengths/time scales assignable to BB.

The energy scale of dark Josephson photons would be that assignable with Josephson junctions of length 10 nm with long wavelengths and energies slightly above E_{th} at physiological temperature. The EUV energy scale would be 120 eV for dark cyclotron photons of highest energy would be fixed by flux tube length of 10 nm.

For lower cyclotron energies forced by the presence of bio-photons in the range containing visible [K14, K15] and UV and obtained for B_{end} below .2 Gauss, the Josephson photons would have energies below E_{th}. That the possible values of B_{end} are below the nominal value $B_{end} = .2$ Gauss deduced from the experiments of Blackman [J1] does not conform with the earlier ad hoc assumption that B_{end} represents lower bound. This does not change the earlier conclusions.

Could the 120 eV energy scale have some physical meaning in TGD framework? The corresponding wavelength for ordinary photons corresponds to the scale $L(151) = 10$ nm which correspond to the thickness of DNA double strand. Dark DNA having dark proton triplets as codons could correspond to either $k = 149$ or $k = 151$. The energetics of Pollack effect suggests that $k = 149$ is realized in water even during prebiotic period [L22] (see `http://tinyurl.com/yalny39x`). In the effect discovered by Blackman the ELF photons would transform dark cyclotron photons having $h_{eff} = h_{gr}$ and energy about .12 keV. They would induce cyclotron transitions at flux tubes of B_{end} with thickness of order cell size scale. These states would decay back to previous states and the dark photons transformed to ordinary photons absorbed by ordinary DNA with coil structure with thickness of 10 nm. Kind of standing waves would be formed. These waves could transform to acoustic waves and induce the observed effects. Quite generally, dark cyclotron photons would control the dynamics of ordinary DNA by this mechanism.

It is natural to assume that $B_{end} = .2$ Gauss corresponds to the upper bound for B_{end} since magnetic fields are expected to weaken farther from the Earth's surface: weakening could correspond to thickening of flux tubes reducing the field intensity by flux conservation. The model for hearing [K10] requires cyclotron frequencies considerably above proton's cyclotron frequency in $B_{end} = .2$ Gauss. This requires that audible frequencies are mapped to electron's cyclotron frequency having upper bound $f_c(e) = (m_p/m_e) f_c(p) \simeq 6 \times 10^5$ Hz. This frequency is indeed above the range of audible frequencies even for bats.

For electron one has $h_{gr}(e) = (m_e/mp) \times h_{gr}(p) \simeq 5.3 \times 10^{-4} h_{gr}(p)$, $\hbar_{gr}(p)/\hbar = 4.5 \times 10^{14}/\beta_0$. Since Josephson energy remains invariant, the Josephson time scales up from $\tau(p) = 5$ seconds to $\tau(e) = (m_e/m_p)\tau(p) \simeq 2.5$ milliseconds, which is the time scale assignable to nerve pulses [K11, K3].

To sum up, the model suggests that the idealization of flux tubes as kind of universal Josephson junctions. The model is consistent with bio-photon hypothesis. The constraints on $h_{gr} = GM_D m/v_0$ are consistent with the earlier views and allows to assign Comorosan time scale 5 seconds to proton and nerve pulse time scale to electron as Josephson time scales. This inspires the question whether the dynamics of bio-catalysis

and nerve pulse generation be seen as scaled variants of each other at quantum level? This would not be surprising if MB controls the dynamics. The earlier assumption that $B_{end} = 0.2$ Gauss is minimal value for B_{end} must be replaced with the assumption that it is maximal value of B_{end}.

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