Life-like properties observed in very simple systems

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Abstract

The physicists working in Emory University have made very interesting discovery. The very simple system studied exhibits what authors call self-organized bi-stability making phase transitions between crystal-like and gas-like phases. The expectation was that only single stable state would appear. Neuron groups can also have collective bi-stability (periodic synchronous firing). Neurons are however themselves bi-stable systems: now the particles are plastic balls and are not bi-stable. One could say that the system exhibits life-like properties. The most remarkable life-like property is metabolism required by the sequence of phase transitions involving dissipation.

Where does the metabolic energy come from? The proposal of the experimenters that stochastic resonance feeds the needed metabolic energy leaves open its source. The resemblance with living cells suggests that the attempt to interpret the findings solely in terms of non-equilibrium thermodynamics might miss something essential - the metabolism.

One can develop a model for the system based on TGD inpired quantum biology. This involves the notion of magnetic body carrying dark matter identified as $h_{eff} = n \times h$ phases; a network of magnetic flux tubes (magnetic body) controlling biological body (now charged plastic balls) and responsible for coherence and synchrony (of the crystal-like phase now); the control of the oscillations of BB by cyclotron radiation (now the plastic ball system) resulting from decays of cyclotron condensates of charged particles (now protons and Ar ions). The source of metabolic energy would come from dark nucleosynthesis explaining nuclear transmutations occurring in living matter and "cold fusion" and serving as source of metabolic energy in prebiotic stage when the chemical energy storage had not yet emerged. Dark analogs of DNA, RNA, tRNA, and amino-acids are dark protons sequences realizing degeneracies of vertebrate genetic code are dark nuclei and can transform to ordinary nuclei and liberate nuclear binding energy so that the hen-egg question about which came first: metabolism or genetic code, is resolved: hen= egg.

There is also second very simple system consisting of particle system with feed of acoustic energy at single wavelength. What happens that the distribution of particles develops synchronous oscillations in wave length band. and the amplitudes are reduced in this band so that wavelength gap emerges. The system is also able to heal. The interpretation is in terms of the emergence of flux tube structure rigidifying the system to pseudo-crystal. The energy of the oscillations of the particles is transferred to MB where it gives rise to Alfwen waves with a wavelength band analogous to atomic energy bands.

1 Introduction

I encountered in FB a link to a rather interesting article by physicists working in Emory University. The title of the popular article was "*Physicists show how lifeless particles can become 'life-like' by switching behaviors*" (see `http://tinyurl.com/y8wrz9ho`).

The article "*Emergent bi-stability and Switching in a Nonequilibrium Crystal*" by Guram Gogia and Justin Burton is published in PRL and can be found in ArXiv [I4] (see `http://tinyurl.com/ychho4l8`). Justin Burton leads a physics group working at Emory University. Guram Gogia who made the discovery is her student.

The physicists working in Emory University have made very interesting discovery. The very simple system studied exhibits what authors call self-organized bi-stability making phase transitions between crystal-like and gas-like phases. The expectation was that only single stable state would appear. Neuron groups can also have collective bi-stability (periodic synchronous firing). Neurons are however themselves bi-stable systems: now the particles are plastic balls and are not bi-stable. One could say that the system exhibits life-like properties. The most remarkable life-like property is metabolism required by the sequence of phase transitions involving dissipation.

Where does the metabolic energy come from? The proposal of the experiments that stochastic resonance feeds the needed metabolic energy leaves open its source. The resemblance with living cells suggests that the attempt to interpret the findings solely in terms of non-equilibrium thermodynamics might miss something essential - the metabolism.

TGD provides a general model for living systems relying on the notion of magnetic body (MB), hierarchy of Planck constants $h_{eff} = n \times h$ labelling phases of ordinary matter identifiable as dark matter, and the realization of control and communication signals between MB and biological body using dark photons [K12, K11]. Bio-photons would result in the transformation of dark photons to ordinary photons and EEG would rely on dark cyclotron photons and generalized Josephson photons from cell membrane (also bio-photons would relate to them). Bose Einstein condensates of dark variants of biologically important ions or their Cooper pairs are also in a central role. The assumption $h_{gr} = h_{eff}$, where h_{gr} is so called gravitational Planck constant, implies that the energy spectrum of dark cyclotron photons is universal (no dependence on the mass of ion) and naturally in visible and UV range characterizing molecular transition energies. [K17, K16].

One can develop a detailed TGD inspired model for the findings leading to an identification of new control tools of MB (MB). Quantum criticality makes it possible for MB can adapt to the biological body (BB) so that it can generated cyclotron frequencies, which correspond to the characteristic frequencies of BB: forced oscillations serve as a control tool of MB. Also the analogs of Alfwen waves identifiable as analogs of string vibrations allow to control the systems at the nodes of the flux tube network.

In the system studied the crystal-like phase corresponds to a connected flux tube network associated having plastic balls as nodes, and gas-like phase to a totally disconnected network with connecting flux tube pairs split into flux loops. That freezing would require energy (going to the magnetic energy of flux tube network in h_{eff} increasing phase transition) does not conform with the thermodynamics of classical systems. That superfluid Helium has similar strange feature at low enough temperatures suggests that the system is indeed quantal. Cyclotron Bose-Einstein (BE) condensates of Cooper pairs of Ar^+ ions, protons, and electrons are proposed to be relevant. Encouragingly, the ratio of frequencies for horizontal and vertical oscillations frequencies of crystal-like structure is equal to the ratio of cyclotron frequencies for Ar^+ and proton.

One of the key challenges is to identify the the prebiotic source of metabolic energy. The sequences of dark protons identifiable as dark nuclei give in TGD framework rise to analogs of DNA, RNA, tRNA, and amino-acids [K4, K5] [L3]. The

model predicts the degeneracies of vertebrate genetic code correctly. In TGD based model for "cold fusion" as dark nucleosynthesis (DNS) serving as a predecessor of ordinary nucleosynthesis dark nuclei transform to ordinary nuclei liberating almost all nuclear binding energy [K15] [L5]. Dark analogs of DNA, RNA, tRNA, and amino-acids would therefore provide also the sought for prebiotic source of metabolic energy in the system studied: the egg-or-hen problem about whether the genes or metabolism came first, would be resolved.

There is also second very simple system exhibiting life-like properties. The system consists of particles with a feed of acoustic energy at single wavelength. What happens is that the distribution of particles develops synchronous oscillations in wave length band below the acoustic wavelength. The oscillation amplitudes are reduced in this band so that wavelength gap emerges. The system is also able to heal. The interpretation is in terms of the emergence of flux tube structure rigidifying the system to pseudo-crystal. The energy of the oscillations of the particles is transferred to MB where it gives rise to Alfwen waves with a wavelength band analogous to atomic energy bands.

2 Experimental findings

The news [I4] is that the system studied exhibits what authors call self-organized bi-stability making phase transitions between crystal-like and gas-like phases. The expectation was that only single stable state would appear. Neuron groups can also have collective bi-stability (periodic synchronous firing). Neurons are however themselves bi-stable systems: now the particles are plastic balls, which are not bi-stable systems. One could say that the system exhibits life-like properties. The most remarkable life-like property is metabolism required by the sequence of phase transitions involving dissipation. Where does the metabolic energy come from?

The durations of the switching time scales are shorter than stable periods and also shorter than predicted by the simulation. The presence of periodicity perturbation, presumably the period for the oscillating phase transition, is suggestive and authors conjecture that there is a weak but yet unidentified periodic signal present required by the proposed stochastic resonance model.

Let us consider first in some detail what the system is and what happens in it.

1. The system studied consists of small charged plastic balls of radius nearly 10 μm (cell size scale) in a cold atmospheric plasma consisting of Argon ions (Ar^+) (see `http://tinyurl.com/yc7q6l7o`). The charged plastic balls consist of melamine formaldehyde (MF) polymers. The plasma is generated using a voltage between electrode and Earth leading to the ionization of Ar to Ar^+: the typical value of voltage is 6 Volt. The electrons from Argon atoms provide negative charge for the plastic balls.

2. Negatively charged BF balls are levitated above the electrode having negative charge given by $Q = CV$, where C and V are the geometrically determined capacitance and the voltage of the ball. In equilibrium position gravitational and electrostatic forces compensate each other when the size of the ball in certain range. Too heavy balls fall down to the electrode and lighter balls

levitate and form a cloud, whose thickness is determined by the variation of the radius of plastic balls. BF balls have mutual repulsive action. The negative charge of the balls is screened by Ar^+ ions with screening characterized by Debye length $\lambda_D \sim 1$ mm. There is also a gradient in the density of Ar^+ ions attracting the balls near the centreof the electrode. The situation is modelled in terms of confining harmonic oscillator potentials in vertical and transversal directions.

3. A crystal-like phase is created by the horizontal confinement. In crystal-like phase collective synchronous oscillations in the vertical direction are initiated so that the equilibrium height of hexagonal plastic ball lattice oscillates. Oscillations are damped by dissipation. The oscillation frequency is determined by the sum of gravitational and electric interaction potentials. The variation c_V of the radius of the plastic ball induces a variation of the mass M and capacitance C and therefore also a variation of the oscillation frequencies f_V and f_H in vertical and transversal directions. The typical values of these frequencies are $f_V = 20$ Hz and $f_H = .5$ Hz. This implies that synchrony of oscillations is lost, and eventually a transition to gas-like phase takes place as nucleation centres for gas-like phase are formed. The gas-like phase dissipates its energy.

   Remark: That the ratio $f_V/f_H = 40$ equals to the ratio of cyclotron frequencies of proton and Ar^+ serves as an important guideline in TGD inspired model.

4. The surprise was that for low pressures and low Ar^+ ion densities a transition to crystal-like phase takes place: this transition correspond to a critical value of the variation c_V for the plastic ball radius. Above the critical value of c_V the system remains in gas phase and below it in crystal-like phase. The crystal-like phase is collectively oscillating in vertical direction, which requires energy feed.

   There is synchrony between the dynamics of plastic balls in crystal-like phase, which is lost and leads to a melting and loss of phase phase coherence between oscillations of plastic balls. Particle system was repeatedly melting and freezing.

5. Since the analog of crystal-like phase is repeatedly generated, there must be a feed of energy to the system analogous to metabolic energy feed in living systems. The proposal of the article is that the energy feed is due to a stochastic resonance [D2]. In stochastic resonance noise amplifies oscillatory signal fed into the system if its frequency f satisfies $f = f(spont)/2$, where $f(spont)$ is the average frequency for the jumps between the bi-stable states of the system due to noise. Since the period of conjectured oscillation is $\tau \sim 100$ s one should have $\tau(spont) \sim 50$ s. The period for this process is considerably longer than for the vertical oscillations. The origin of this self-induced oscillation required by stochastic resonance model is not understood and one can even challenge its existence.

Remark: From the point of view of quantum biology it might be highly relevant that plastic balls consists of organic molecules. BF molecules involve aromatic 6-

cycles appearing also in DNA. There is negative charge associated with the plastic balls. Also DNA carries negative charges associated with phosphate ions.

3 Basic ideas of TGD inspired quantum biology

TGD Universe is quantum critical and quantum criticality involves universal dynamics. This raises the hope that also the TGD inspired model of living systems is universal and applicable also in the recent context. The findings would provide a test for TGD view and even allow to sharpen it. TGD based view about living systems involves several new notions.

3.1 Dark matter as hierarchy of phases of ordinary matter with $h_{eff} = n \times h$

The first new element is the hierarchy of Planck constants $h_{eff}/h = n$. In adelic physics [L8, L9] proposed to provide physical correlates of both sensory experience and cognition $h_{eff}/h = n$ serves as a kind of IQ for the system measuring its algebraic complexity (n could correspond to the order of the Galois group for the extension of rationals defining the adele in question).

1. Quantum criticality is the basic property of TGD Universe and also an essential aspect of what it is to be living in TGD Universe and the associated long range fluctuations and correlations correspond to large values of $h_{eff}/h = n$ for the flux tubes of MB [K16]. The increase of $h_{eff}/h = n$ keeping magnetic field strength un-affected reduces binding energies for electrons of atoms and increases cyclotron energy scale and scales up quantum lengths and times, in particular the scales of quantum coherence and this kind of phase transitions seem to be crucial in TGD inspired biology.

   The energies of subsystems indeed typically increase with h_{eff}. For instance, atomic binding energies are proportional to $1/h_{eff}^2$. Cyclotron energies are in turn proportional to h_{eff}.

   The function of metabolism in TGD Universe is to increase the value of h_{eff} for some sub-systems of living system, and therefore to increase the complexity of the subsystem. The reduction of h_{eff} liberates energy and this energy could kick the reacting molecules over the potential wall in bio-catalysis. The reduction of n forcing the shortening of the flux tubes could provide a mechanism allowing the reacting biomolecules to find each other in a dense molecular soup.

2. The cyclotron frequencies of dark ions in the magnetic field of the flux tubes do not depend on $h_{eff}/h = n$ but the cyclotron energies $E_c = h_{eff} \times f$ are scaled up by factor n so that they are above thermal energy at physiological temperatures and can carry information so that they can be used for communication and control purposes. Cell membrane acts as a generalized Josephson junction and dark Josephson radiation communicates sensory information to MB coded to the modulation of the generalized Josephson frequency by the variations of neuronal membrane potential induced by nerve pulse patterns [K10, K3].

3.2 $h_{gr} = h_{eff}$ hypothesis and universal cyclotron energies

$h_{gr} = h_{eff}$ hypothesis [K17, K16] and its generalizations such as e $h_{em} = h_{eff}$ represent a further key element of the TGD inspired model of living matter. This relationship is proposed to hold when the coupling strength proportional to appropriate charges is so large that perturbation series does not converge. The large value of h_{eff} reduces the value of coupling strength proportional to $1/h_{eff}$ so that dark matter satisfying this condition would allow a perturbative description.

1. Nottale [E1] introduced originally the notion of gravitational Planck constant $\hbar_{gr} = GMm/v_0$ to explain the orbital radii of planets in solar system as Bohr orbits. The value of the velocity parameter v_0/c is of order $2^{-11} \simeq .5 \times 10^{-3}$ for the inner planets. The interpretation in TGD framework is that the magnetic flux tubes mediate gravitational interaction between masses M and m and the value of Planck constant is h_{gr} at them.

   The proposal $h_{eff} = h_{gr}$ at flux tubes is very natural sharpening of the original hypothesis [K16, K17]. The predictions of the model do not depend on whether m is taken to be the mass of the planet or any elementary particle associated with it and the gravitational Compton length $\lambda_{gr} = GMc/v_0$ does not depend on the mass of the particle, and is proportional to the Schwartschild radius $r_S = 2GM$ of Sun. This encourages the idea about astroscopic quantum coherence at magnetic flux tubes mediating gravitational interaction. One of the applications is to the fountain effect of superfluidity [K16].

   In the biological applications the identification of mass M as Earth mass is one possibility but there are also other options [K17]. The identification of v_0 as some mechanical velocity scale looks natural.

2. $h_{gr} = h_{eff}$ hypothesis predicts that cyclotron energies do not depend on the mass of the particle whereas cyclotron frequencies are proportional to $1/m$. Cyclotron energy spectrum would be universal and correspond to the spectrum of magnetic field strengths B. Bio-photons with energies in visible and UV are proposed to result as dark photons satisfying $h_{gr} = h_{eff}$ transform to ordinary photons. For $B = B_{end} = 2B_E/5$ ($B_E = .5$ Gauss is the nominal value of the Earth's magnetic field) the hypothesis fixes the scale of cyclotron frequencies and h_{gr} should be in the range $10^{12} - 10^{14}$.

3.3 MB (MB) and its motor actions

A further new element is the notion of MB (MB) adding to the pair formed by organism and environment a third member. This brings into biochemistry a radically new element [K12, K11]. One can say that MB uses biological body as a motor instrument and sensory receptor.

1. In TGD standard model gauge fields and gravitational field are replaced locally by the 4 imbedding space-time coordinates behaving like field variables. This implies an enormous simplification of the local dynamics however lost in the QFT limit replacing many-sheeted space-time with a slightly curved region of

M^4. A further simplification comes from preferred extremal property [K18, K20, K21].

2. At the level of space-time topology the situation becomes however extremely complex. Gauge fields created by the system are replaced with field body consisting of topological field quanta (space-time sheets) so that one can assign to a system well-defined field identity - field body. One has a fractal hierarchy of field bodies within field bodies. Magnetic flux quanta represent one example of topological field quantization.

   System has therefore besides its biological body (BB) also MB (MB) carrying dark matter particles identified ordinary particles with scaled up Planck constant $h_{eff}/h = n$ implying scaling up of various quantum length and time scales (by factor n in the simplest situation). MB has a hierarchical onion-like structure corresponding to various p-adic length scales and various values of h_{eff}.

MB can control BB by "motor actions" in which the length L and possibly also the area S of flux tubes change [K12]. This affects string tension and amplitude of oscillations of systems connected by magnetic flux tubes so that motor action of BB is induced. The phase transition changing the field strength could be induced by a phase transition changing h_{eff}: if magnetic flux is monopole flux it is conserved. There are two options.

1. The scaling $(S, L) \to n \times (S, L)$ leaves L/S invariant and scales down the magnetic field strength as $B \propto 1/S \to B/n$. Magnetic energy and cyclotron energies are unaffected but cyclotron frequencies f_c scale down as $f_c \to f_c/n$. There is quantum criticality corresponding to flux tubes with same value of L/S in the sense that these systems have same energies. This kind of quantum criticality could occur at critical values of relevant parameters.

   Quantum criticality makes it possible for MB to tune its cyclotron frequency spectrum so that it corresponds to a given set of frequencies associated with BB. MB can control the corresponding oscillatory processes at BB by using dark cyclotron radiation transformed to bio-photons as a resonant driving force. Dark cyclotron radiation would result from the decay of dark cyclotron BE condensates. MB would thus adapt to the properties of BB. The larger the maximal value of n, the wider the variety of different adaptations, the higher the ability of the system to survive, and the higher the evolutionary level of the system.

   The cyclotron energy spectrum associated with EEG could also entrain to various frequencies assignable to the neural circuits and in this manner MB would gain a control over them. Entrainment occurring at the level of brain would be second example of this process. MB learns to mimic the processes occurring at the level of BB and in this manner gains control over them. MB also learns how to get information about them. The motor actions of MB allowing to change the thickness and length of the flux tubes would be essential for achieving this.

Remark: In the case studied the frequencies f_V and f_H assignable to the oscillations of plastic balls would correspond to frequencies at level of BB to which MB tunes by a suitable choice of h_{eff}.

2. For $(S, L) \to (S, n \times L)$, magnetic field remains invariant so that cyclotron frequencies are unaffected. Magnetic energies and cyclotron energies are scaled up by n: one might say that one has criticality in classical sense. This kind of transitions require energy and are analogous to first order thermodynamical phase phase transitions.

   Remark: In the case studied the phase transition from gas to crystal-like phase of plastic balls would correspond to the increase of h_{eff} leaving the frequencies invariant and would thus require energy in contrast to the usual view that energy is liberated in freezing (Helium superfluids are the only exception to the rule, and are macroscopically quantum coherent systems).

3. The decay of cyclotron BE condensates at MB generates dark cyclotron radiation, which can transform to ordinary radiation and drive oscillatory processes at BB [K13, K14]. This provides an additional control mechanism. Dark photons can transform to ordinary ones in several manners. The following special cases are diametric opposites of each other and correspond to $n \leftrightarrow 1$ transitions. More general transitions are of type $m \leftrightarrow n$.

   (a) Dark photon with energy $E = h_{eff} \times f$ can transform to ordinary photon with same energy and frequency $n \times f$. Bio-photons would result from low frequency dark photons - even dark EEG photons - in this manner. Bio-photons are in visible and UV range and biomolecules have excitation energies in this range so that MB could control bio-chemistry in this manner.

   (b) Dark photons with energy $E = h_{eff} \times f$ can decay to a bunch of n ordinary photons with the same frequency f but energy E/n. This could allow MB to control electromagnetic and mechanical oscillations taking place at low frequencies.

   Also transformation which reduce Planck constant but do not lead to $n = 1$ state are possible.

   Remark: In the case studied the decay of BE condensates to ordinary ELF photons could allow the control of the oscillations of plastic balls.

4. Alfwen waves (see `http://tinyurl.com/7ekxqt2`) are part of the dynamics of ordinary Maxwellian magnetic field often described phenomenologically as oscillations of magnetic flux tubes. The phase velocity $v = c/\sqrt{\epsilon}$ is light velocity in vacuum modified by the dielectric constant $\epsilon = 1 + \rho/B^2$ (one has $c = 1$, $\epsilon_0 = 1$,and $\mu_0 = 1$ in the units used) caused by the total mass density of charged matter and energy density magnetic field.

   Alfwen waves generalize in TGD framework to oscillatory perturbations of the magnetic flux tubes, which in 1-D approximation for flux tubes can be modelled by transversal vibrations of string characterized by string tension

proportional to L/S. In longitudinal directions the vibrations are in the interior of string trivial but induce oscillations of the distance between the ends of the string and are thus visible in the dynamics of BB.

Remark: In the recent situation Alfwen waves would naturally affect the dynamics of plastic balls in the crystal-like phase if flux tubes connecting the plasma balls are present.

5. The motor actions of MB can also change the topology of MB. BB is assumed to posses closed U-shaped flux tubes acting as kind of tentacles scanning the environment and re-connecting with the U-shape flux tubes associated with other systems to form pairs of flux tubes connecting two systems [K5, K6, K7]. These reconnections would serve as a topological correlate for a directed attention and for entanglement between the systems at the ends of the flux tubes. For instance, immune system would have developed from this kind of scanning of the environment.

   One can imagine even more radical magnetic "motor actions". At given level of hierarchy of space-time sheets space-time sheets of sub-systems can be connected by a network of magnetic flux tubes [L4]. The connectedness of the flux tube network can change by the re-connection process and its reversal. The increase of h_{eff} affects the size of the closed loops and can induce their reconnections to flux tube pairs connecting the systems at its ends. The reduction h_{eff} can induce the reversal of reconnection and split the flux tube pair to two flux loops. This gives rise to quantum analogs of phase transitions between crystal-like and fluid-like phases.

   Remark: In the case studied the formation of crystal phase from plastic balls could correspond to the re-connection of flux loops assignable to plastic balls to form kind of tensor network correlating the dynamics of plastic balls. Its reversal would lead to gas phase.

3.4 Dark nucleosynthesis (DNS) as a source of metabolic energy in prebiotic systems?

One of the key challenges is to identify the prebiotic source of the metabolic energy. The sequences of dark protons identifiable as dark nuclei give in TGD framework rise to analogs of DNA, RNA, tRNA, and amino-acids. In TGD based model for "cold fusion" as dark nucleosynthesis (DNS) proposed to serve as the predecessor of ordinary nucleosynthesis these dark nuclei transform to ordinary nuclei liberating almost all nuclear binding energy [K15] [L5]. DNS could provide the sought for prebiotic source of metabolic energy and also a source of metabolic energy in the system studied.

1. There is a considerable evidence for the production of energy in what is known as "cold fusion" not allowed by the standard nuclear physics [L2, L5]. As a matter of fact, cold fusion is definitely *not* in question, which has motivated the introduction of the term low energy nuclear reactions (LENR). What definitely occurs are nuclear transmutations, that is formation of nuclear isotopes not present in the original system. Also energy is produced [C4, C3].

The typical experimental arrangement involves electrolysis in which one has a voltage between electrodes inducing the ionization of hydrogen or deuterium. The positive ions flow towards the negatively charged cathode and the transmuted elements appear at the cathode and also heat is produced. Now one has negatively charged electrode and also plastic balls are negatively charged being thus analogous to cathode with a negative surface charge. Ar^+ ions could take the role of protons or deuterium ions. Also protons could be present.

2. I have been recently working with a detailed model for "cold fusion" [L2, L5] [K15]. In Widom-Larsen model (WL) [C1, C6] to LENR only standard model of nuclear interactions is used but some unrealistic looking assumptions must be made. Remarkably, there is also evidence that the transmutations take place also in living matter [C2, C5] and the question is whether nuclear transmutations could provide a new source of metabolic energy.

TGD based model involves new physics and relies on DNS involving the formation of dark proton sequences at magnetic flux tubes of MB of the system [L2]. Dark proton sequences would be dark nuclei and would suffer rapidly occurring dark beta decays replacing some dark protons with dark neutrons. Dark nuclei would transform to ordinary nuclei and liberate almost all of ordinary nuclear binding energy in the process. Most of the energy could go to the magnetic flux tubes possibly leading out of the system and would be lost. The flux tubes entering to the negatively charged surfaces such as some regions of cathode would be an exception.

Could stable light nuclei fuse to heavier ones by forming dark nuclei consisting of weakly bound ordinary nuclei transforming to ordinary nuclei also in living matter? If dark weak decays are not involved, both (A, Z) are additive in the process. If dark weak decays are allowed, only A is additive. If these fusion reactions produce the biologically important ions, A and possibly also Z for the nuclei of biological ions would form an additive group with some basic nuclei serving as generators.

1. If proton is taken as an additive generator, the situation is trivialized. On the other hand proton, is not a genuine nucleus, and ordinary nuclei of form $A = Z$ are also unstable. It is however to add dark protons to an ordinary nucleus at magnetic flux tubes to get $(Z, A) \to (Z + 1, A + 1)$ suggested by Widom and Larsen to be a basic process. Dark proton could suffer dark weak decay with a scaled up rate since dark weak bosons are effectively massless below the size scale defined by their scaled up Compton length. This mechanism is central in both WL model of LENR and in TGD based model of DNS [L5].

2. $He(2, 4)$ is the basic product in DNS and because its large binding energy would be a natural generating nucleus. The resulting nuclei would have $(Z, A) = n \times (2, 4)$. A is always even for these nuclei. The nuclei C, O, Ne, Mg, S, Ar, Ca are all stable and correspond to $n = 3, 4, ..., 10$. C, O, Mg, S, Ca are of central importance in living matter. $Be(4, 8)$ with $n = 2$ is missing from the list. The reason is that it has very short life-time against alpha decay whereas energy conservation prevents alpha decays of the heavier nuclei in sequence.

3. $D(1, 2)$ is the lightest non-trivial candidate and would give nuclei of form $(Z, A) = n \times (1, 2)$. The binding energy of D is however rather small. The nu-

clei formed as multiples of $He(2,4)$ can be formally regarded as even multiples of $D(1,2)$ (only formally, because the binding energy per nucleon for $He(2,4)$ is considerably larger than for $D(1,2)$). The odd multiples correspond to stable isotopes $Li(3,6)$, $B(5,10)$, $N(7,14)$ corresponding to $n = 3,5,7$. $F(9,18)$ decays to stable $O(8,18)$, $Na(11,20)$ decays to stable $Ne(10,20)$, and $Al(13,26)$ to stable $Mg(12,36)$. This reflects the fact that for stable heavier isotopes the number of neutrons is larger than number of protons.

4. $Li(3,6)$ is stable albeit not the most abundant isotope of Lithium. C, F, Mg, P, Ar have isotope of form $n \times (3,6)$ with $n = 2,3,..,6$. Most of these nuclei are obtained from $He(2,4)$. The isotopes $F(9,18)$ and $P(15,30)$ are unstable and decay by beta decay to to stable $O(8,18)$ and $Si(14,30)$ respectively.

5. One can also form sums of different nuclei: $(Z,A) = (Z_1,A_1) + (Z_2,A_2)$.

   (a) The simplest sum corresponds to $(Z_2,A_2) = (1,2) = D$. This addition is especially natural for nuclei which are multiples of $He(2,4)$. This allows to transform isotopes $H(2,A)$ to $Li(3,A+2)$ and $Li(3,A)$ to $Be(4,A+2)$, $Be(4,A)$ to $B(5,A+2)$, $B(5,A)$ to $C(6,A+2)$, $C(6,A)$ to $N(7,A+2)$, and $N(7,A)$ to $O(8,A+2)$. $O(8,A)$ cannot be transformed to a stable isotope $F(9,A+2)$.

   (b) The addition of dark proton to a stable nucleus ($(Z+1,A+1) = (Z,A)+p$ is the key mechanism of WL model and conforms with the basic vision about the DNS as formation of dark proton sequences and addition of dark protons to an ordinary nucleus at the flux tube.

   For instance, one has $Na(11,23) = Ne(10,22)+p$, $P(15,31) = Si(14,30)+p$, $S(16,31) = P(15,30)+p$, $Cl(17,35) = S(16,36)+p$, $K(19,39) = Ar(18,38)+p$, and $Mn(25,44) = Cr(24,54)+p$). All nuclei except $P(15,30)$ appearing in the initial state are stable. $P(15,20)$ suffers (perhaps dark) beta decay to Si(14,30), which is stable. This however does not prefent the addition of proton to take place.

   $Fe(26,56)$ is an important biological ion and could be obtained from $Fe(26,52)$ by an addition of four dark protons with subsequent dark weak decays of proton to neutron. $Fe(26,52)$ is unstable against beta decay to $Mn(25,52)$ in turn unstable about beta decay to $Cr(24,52)$, which is stable.

   (c) One can consider also sums of heavier isotopes. For instance, the sums $K(19,39) = O(8,16)+Na(11,23)$ and $Ca(20,40) = O(8,16)+Mg(12,24)$ are stable biologically important nuclei obtained as sums of stable biologically important nuclei. Biologically important nuclei $Na(11,23)$, $P(15,31)$, $S(16,31)$, $Cl(17,35)$, $K(19,39)$, $Mn(25,55)$ have odd value of A so that they are not obtained as sums of the nuclei constructed using the rules discussed above.

To sum up, that the nuclei obtained as multiples of $He(2,4)$ correspond to several biologically important nuclei can be seen as an indication that dark fusion of at least $He(2,4)$ nuclei takes place in living matter.

4 TGD based explanation for the life-like aspects of the system

The system under study [I4] indeed has several features bringing in mind living cell as it is understood in TGD.

1. The situation is in some aspects analogous to that prevailing over the cell membrane. Cell membrane is analogous to a battery providing metabolic energy for the system via ATP-ADP process. Could the voltage between electrodes creating Ar^+ plasma have analogous function? It seems however that DNS is the what provides the metabolic energy. Ar^+ could be analogous to biological ions such as K^+. The negative charges from Ar atoms are received by plastic balls or even the space-time sheet containing them.

2. Charged plastic balls consisting of melamine formaldehyde (MF) polymers are somewhat analogous to biomolecules such as DNA sequences, which also carry negative charge. The charged plastic balls consisting of MF (see `http://tinyurl.com/z532ryv`) are organic matter. MF contains aromatic 6-cycle appearing also in important biopolymers such as RNA and DNA. Perhaps the plastic balls are not so simple systems as the non-equilibrium thermodynamics based model of experimenters assumes. Could their molecular structure have something to do with the observed life-like aspects of the system? In particular, could the molecular structure make possible the generation of dark proton sequences at flux tubes?

3. The system dissipates and must receive metabolic energy from some source. The metabolic energy feed seems to take place with average period τ of about 100 s. Stochastic resonance requiring periodic oscillation amplified by the stochastic signal is not the only possible explanation. In TGD inspired quantum biology metabolic energy feed induces increase of h_{eff}. The increase of h_{eff} would increase the scale of quantum coherence and make the system crystal-like so that the plastic balls oscillate in synchrony. DNS provide an obvious candidate for the origin of the metabolic energy.

These observations motivate a quantum approach different from the approach based on non-equilibrium thermodynamics and stochastic resonance.

4.1 Self-organized bi-stability or oscillations driven by cyclotron radiation and energized by DNS?

The theoretical approach of the experimenters relies on the notions used to describe far-from-equilibrium systems using generalization of thermodynamics. The vision is that the dynamics of complex systems has universal features. Conservative force (gravitational force and electric forces between plastic balls and electrodes and plastic balls), dissipation and stochastic force would be present.

Remark: No driving force is assumed: this would describe the damped oscillations but cannot explain the repetition of the phase transitions.

Stochastic resonance would feed metabolic energy to the system inducing the jumps over potential wall making possible the transitions between the two phases, amplify the vertical and horizontal oscillations, and also give kinetic energy for the plastic balls in gas-like phase.

The summary of the article gives a technical description of the discovery.

The experiments and simulations presented here display a broad class of non-equilibrium phenomena in a single system with minimal ingredients and rich dynamics. We have experimentally demonstrated global bi-stability in a spatially-extended system com- posed of non-bi-stable elements. Given the underlying first-order phase transition between the condensed and gas-like phases, our experiment may be a realization of self-organized bi-stability. The inter-state switching is facilitated by both quenched disorder and dynamical noise. The time scales of individual stable and un-stable periods are not symmetric. Durations of instability are mostly determined by the damping time, whereas the stability durations can be much longer and depend on the nucleation of an energy-redistribution event. This is a common property in many excitable systems, where the relaxation path is more deterministic than the excitation path. However, the distribution of switching timescales in the experiment is narrower than in the simulation. This may be due to a weak periodic signal in the experiment which couples with the noise to induce switching. The source of the periodicity, in addition to controlling the vertical oscillations through modulating the electrode voltage, are subjects of current investigation in our lab.

In the sequel the model is analyzed to identify its possible weaknesses in order to see how TGD inspired quantum approach could allow to circumvent them.

4.1.1 Thermodynamical aspects

The authors assume that the transitions involved are analogous to first-order phase transitions (heat is absorbed or liberated and the transition occurs at constant temperature and regions of both phases are present) between condensed and gas-like phases. Could simple thermodynamical analogies for the transitions between condensed and gas-like phases help to understand the situation?

1. Melting and evaporation require usually heating. Enthalpy of fusion is the quantity describing the energy needed by the heating. It is usually positive (in liquid and gas phases molecules have larger thermal energy than in solid phase). Only for ^3He and ^4He super-fluids at sufficiently low temperatures the enthalpy of fusion for melting is negative (see `http://tinyurl.com/pfr84c3`). Also in the recent situation the generation of the damped oscillations would suggest that the enthalpy of fusion is negative.

   Positive enthalpy of fusion for melting requires that energy is fed into the system. It however seems that nucleation centres are generated by the variation of oscillation frequency and that the process occurs spontaneously and transfers energy from the degrees of freedom responsible for the bonding of balls to crystal-like phase to the kinetic energy of balls. Therefore the situation resembles that for Helium superfluid at low temperatures also in this respect. Some additional degrees should be present.

2. Could thermodynamical analogy help to understand what happens in the phase transition between gas-like and crystal-like phases. Freezing usually liberates heat but since heat correspond to completely disordered motion it seems highly implausible that this heat would go to the ordered collective motion of the crystal-like phase.

   In heat engines the amount of heat transformable to work is by second law of thermodynamics below $\gamma = \Delta T/T_h$, where ΔT is temperature difference and T_h the higher temperature. To have synchronous oscillations due the liberated heat, looks highly implausible. If work is done, it must be done by additional degrees of freedom receiving energy and providing it as energy required by the excitation of damped oscillations of crystal-like phase. This option seems plausible.

If one wants to use thermodynamical analogies, it seems that one must assume that there are additional yet un-identified degrees of freedom and a yet un-identified source of energy pumping energy to these degrees of freedom.

4.1.2 The analogy with Helium supra phases

Consider now the analogy with Helium supra phases (see `http://tinyurl.com/zs8rpjm` and `http://tinyurl.com/pfr84c3`).

1. In TGD framework the obvious identification of the additional degrees of freedom is as those associated with magnetic flux tubes of MB forming a network in crystal-like phase. The flux tubes and the cyclotron BE condensates of ions at them would carry energy.

2. The generation of crystal-like phase would require energy. As noticed, this implies resemblance with He^3, in which Cooper pairs give rise to a superfluidity suggesting that the system behaves as a macroscopic quantum system. Cooper pairs of Ar^+ ions could form an analog of super-fluid or super-conductor. Also Cooper pairs of electrons and protons coming from plastic balls could form super-conductors. In TGD framework the members of Cooper pairs would be located at parallel magnetic flux tubes connecting plastic balls [K1, K2, K8, K9].

3. In the transition to gas phase this network would be destroyed as the reconnections between MBs of plastic balls are split and give rise to nucleation regions for gas phase. The splitting would liberate magnetic energy and also energy of cyclotron BE condensates if the value of h_{eff} is reduced. This energy would transform to the kinetic energy of the plastic balls. Therefore the phase transition would liberate energy and would be analogous to the corresponding transition for ^3He. Note that also the TGD based model for supra phases of Helium involves magnetic flux tube network [K16].

4. The phase transition should change the values of $h_{eff}/h = n$ but leave cyclotron frequencies un-affected and thus involve energy feed so that first order phase transition would be in question.

4.1.3 The mechanism inducing vertical and horizontal oscillations of plastic balls

One should identify the mechanism giving rise to the vertical and horizontal oscillations of plastic balls.

1. The authors of the article [I4] propose an identification for the interactions involved. TGD approach suggests additional interaction due to the string tension of the flux tubes giving rise to elastic force and additional interaction energy. As already noticed, the model of authors does not assume resonant driving force although they mention of having tried it. The probable reason for giving up this option is that it allows only the decay of crystal-like phase to gas-like phase but not a repetitive cycle.

2. The ratio $f_V/f_H \simeq 40$ for typical vertical and transversal oscillation frequencies equals to the ratio $m(Ar^+)/m(p) \simeq 40$, which suggests that BE condensates of Cooper pairs of both Ar^+ and protons are indeed present at flux tubes. The condition that cyclotron frequencies are in question, fixes the value of magnetic field strength to $B = B_{end}/15$, where $B_{end} = 2B_E/5 = .2$ Gauss is an endogenous magnetic field assumed be important value of magnetic field in TGD inspired quantum biology and inspired by findings of Blackman and others [J1, J2]. $B_E = .5$ Gauss is the nominal value of the Earth's magnetic field.

   p-Adic length sale hypothesis slightly favors the value $B = B_{end}/16$, which corresponds to the magnetic length $L_B = \sqrt{\hbar_{eff}/eB} = 4L_{B_{end}} = 22.8$ μm (from $L_{B_{end}} = 5.7$ μm) to be compared with the size $d \simeq 10$ μm of the plastic balls.

   One can estimate also the classical cyclotron radii from the formula $r_c = mv/eB = p/QB$, where v is the velocity of the charged particle. For cyclotron orbits with principal quantum number n Bohr quantization gives $r_c = \sqrt{n}L_B$, where $L_B = \sqrt{\hbar/QB}$, is magnetic length. Note that orbits with same radius are possible for $h_{eff}/h = n_i$. $i = 1, 2$ if one has $n_1 = nn_2$ or vice versa.

3. This suggests a mechanism generating vertical and transversal and horizontal oscillations of the plastic balls. The cyclotron radiation resulting in the decay of the BE condensates drives the oscillations resonantly by oscillatory force $F = F_0 \times exp(i\omega t)$ so that one obtains the oscillation amplitude as a sum of damped oscillation amplitude $exp(-\Gamma t)exp(i\omega t)$ and resonance term proportional to $exp(-\Gamma t)exp(i\omega t)t$ increasing in oscillatory manner up to time value $t \sim 1/\Gamma$ and decreasing after that exponentially. The parameters F_V and F_H would be additional parameters in TGD based model.

   Remark: This mechanism could be quite general mechanism of quantum biology.

4. The variation of the plastic ball radius induces a variation of mass and charge of the ball and therefore also a variation of the oscillation frequencies f_H and f_V, which can be however compensated by the variation of the magnetic field strength B at flux tubes inducing variation of string tension and elastic

constant so that synchronous oscillations are possible. This is possible only for c_V below some critical value. For larger values the compensation is not possible, and the oscillations lead to gas phase. For smaller values the solid phase is stable. At (quantum) criticality the metabolic cycle becomes possible.

5. The oscillations of plastic balls could be induced by the analogs of Alfwen waves for the magnetic flux tubes which in 1-D approximation for flux tubes would be essentially vibrations of string characterized by string tension proportional to L/S. The energetics of the system would be invariant under changes of $h_{eff}/h = n$ if L and S scale like n, and one would have quantum criticality allowing MB to adapt to the properties of the plastic ball system. A network consisting of springs would provide an analog system. The decay of cyclotron BE condensates would feed energy to the vibrations of string in turn feeding energy to the oscillations of plastic balls. Both energy feeds could be modelled in terms of forced oscillations.

   Quantum criticality would make possible for MB to adapt to the properties of the part of the system consisting of ordinary matter by a proper selection of n since one has $f_c \propto n$ for the same energetics. For given value of B different charged dark particles have different cyclotron frequencies but same energies at quantum criticality. Also the $h_{gr} = h_{eff}$ condition implies that the cyclotron energies do not depend on particle mass and therefore implies quantum criticality.

4.1.4 The energetics of the system

The energetics of the system demands an analog of metabolic energy feed.

1. Authors assume that stochastic resonance provides the needed energy feed but its origin remains open. Stochastic resonance requires an additional oscillator with period about $\tau = 100$ s. According to the authors, the problems of their model are that the transition periods seem to be too short and also the times spent in stable and transition states are not symmetric as they should be in bi-stable system. Also the prediction for the frequency $f = 1/\tau$ tends to be too short.

2. To get the metabolic cycle with forced oscillations without stochastic resonance, one needs a kick providing the energy inducing a phase transition to the crystal-like phase, which also oscillates as a whole thanks to this energy feed. In TGD framework the needed energy dose could be provided by dark nucleosynthesis (DNS) involving formation of dark proton sequences containing perhaps also Ar^+ ions and transforming to ordinary nuclei. The transition could be rather fast and occur in the minimal case only once during the single metabolic cycle of about $\tau = 100$ s so that one would have $\tau \sim 1/\Gamma$, where Γ is the average rate for DNS. Also the phase transition splitting the flux tube pairs by de-reconnection could be rather fast as compared to τ.

   Remark: The periodic signal with frequency $f = 1/100$ Hz is not necessary.

3. Dark cyclotron radiation with $h_{eff}/h = n$ could transform to ordinary photons with energy, which is n-multiple of ordinary cyclotron energy. If n is large enough the photons have energies above thermal energy. In living matter the values of n are in the range $10^{12} - 10^{14}$ so that the cyclotron energies correspond to bio-photon energies in visible and UV range characterizing the transition energies of bio-molecules. If $h_{gr} = h_{eff}$ hypothesis holds true the cyclotron energies do not depend on mass of the charged particle. Also a decay to bunches of n of photons with ordinary energy is possible. Both mechanisms could be involved. The bunches of n ordinary quanta could drive electromagnetic oscillations and mechanical (acoustic) oscillations. In piezoelectrets populating living matter the transformation of electromagnetic and acoustic oscillations to each other is possible.

4. The rate Γ of DNS events is in the first approximation proportional to the number of plasma balls events if the DNS even for single ball feeds energy for the entire system. Γ cannot be much lower than $f_c(Ar^+) = .5$ Hz since the system would remain to crystal-like phase. It Γ is too high, the transition to gas phase becomes impossible.

4.1.5 Is the frequency $f \sim .01$ Hz needed in TGD based model?

It is not at all clear whether frequency $f \sim .01$ Hz required by the stochastic resonance model is needed nor even possible as a cyclotron frequency in TGD inspired model.

1. If f is present, one can wonder whether it could be associated with the cyclotron BE condensate at the magnetic bodies of plastic balls. Could the plastic balls at some level in the hierarchy of space-time sheets behave like particles in quantum sense (the space-time sheet assignable to the plastic ball)? Does it make sense to talk about crystal-like phase as a kind of cyclotron BE condensate of charged plastic balls? Or is there energy feed from quantal cyclotron degrees of freedom assignable to the magnetic flux tubes to classical degrees of freedom of plastic balls?

2. The simplest working hypothesis to be killed is that both plastic balls, protons, and Ar^+ ions are at the same flux tubes of MB so that the value of magnetic field is fixed to about $B_{end}/15$, $B_{end} = .2$ Gauss. The order of magnitude for the cyclotron frequency turns out to be several orders of magnitude lower than $f = .01$ s. Hence it seem that there is no obvious manner to introduce $f \sim .01$ Hz in the model.

The following little calculation gives the estimate.

1. One has $f_c = QB/2\pi M$, where $Q = CV$ and C is the capacitance of the plastic ball. C is purely geometric parameter and for single ball with radius d embedded in dielectric with relative permittivity ϵ_r it is determined by the value of Coulomb potential $V_c = Q/4\pi\epsilon$ at the surface of the ball. This gives

$$C/Farad = 4\pi\epsilon d = \epsilon_r \times (d/meter) \times 5.224 \times 10^{-12} \ .$$

2. The mass of the ball is given by $(4\pi/3)\rho d^3$, where ρ is the density of the ball which in an approximation needed for order of magnitude estimates given by

$$\rho = \frac{m_p}{a^3} \quad , \quad \frac{a}{Angstrom} = 1$$

3. From this one obtains for the cyclotron frequency the expression

$$f_c(ball) = 3 \times \epsilon_r \frac{d}{meter} \times (\frac{a}{d})^3 \times \frac{V}{Volt} \times \frac{B}{B_{end}} \times 3.3 \times 10^7 \times f_c(p, B_{end}) \ ,$$
$$f_c(p, B_{end}) = \frac{eB_{end}}{m_p} = 300 \ Hz \ .$$

Using the values

$$\frac{V}{Volt} = 6 \ , \quad \frac{d}{meter} = 10^{-5} \ , \quad \rho = \frac{m_p}{a^3} \ , \quad B = \frac{B_{end}}{15}$$

this gives the estimate

$$f_c(ball) \simeq \epsilon_r \times 5.8 \ days \ .$$

For vacuum with $\epsilon_r = 1$ the frequency is smallest possible. It is not possible to obtain $f_c \sim .01$ Hz for reasonable strength of B.

What about cyclotron frequencies of cells and cell membranes assuming $B = B_{end}$?

1. Cells are also negatively charged but the charge of the cell is rather small (see `http://tinyurl.com/yb9w6nqs`)- about 10^3 e for yeast cell so that Q/M ratio is very small.

2. What about cell membrane treated as single unit? The capacitance per unit area does not depend much on cell (see `http://tinyurl.com/chylvs9`) being given in good approximation by

$$c = \frac{dC}{dS}\frac{cm^2}{Farad} = 2 \times 10^{-6} \ .$$

The capacitance is from this given by $C = c \times S$. Assuming spherical symmetry, the estimate for the cyclotron frequency $f_c(membrane)$ is

$$f_c(membrane) = 3c \times a^2 \times \frac{a}{d} \times f_c(proton, B_{end}) \times \frac{Coulomb}{e} \times \frac{V}{Volt} = 1.5 \times 10^{-7} \times \frac{10\mu m}{d} \times \frac{B}{B_{end}} \times$$

For $d = 10$ μm and $B = B_{end}$ and $V = .05$ Volt the cyclotron time is 77.2 days. For DNA sequences the cyclotron frequencies are around 1 Hz irrespective of their length.

4.1.6 Some observations about Argon ions

A couple of comments about the possible role of Argon are in order.

1. I ended up with the recent vision about living matter on basis of observations that the radiation at cyclotron frequencies of Ca^{++} ions and also other biologically important ions have effects on physiology and behavior of vertebrates [K12, K11]. The magnetic field involved was $B_{end} = 2B_E/5$, where $B_E = .5$ Gauss is the nominal value for the magnetic field of Earth. The cyclotron frequencies of Ca^{++} in B_{end} are multiples of $f_c(Ca^{++}) = 15$ Hz. Ca has $(20, 40)$ whereas Ar^+ has $(A, Z) = (40, 18)$. Therefore the cyclotron frequency of Ar^+ (which is fermion) is in good approximation one half of that for Ca^{++}: $f(Ar^+, B_{end}) = f_c(Ca^{++})/2 = 7.5$ Hz. TGD based model for high Tc and bio-superconductivities suggests that Ar^+ ions could form Cooper pairs with members at flux tubes with opposite directions of magnetic field.

   What puts the bells ringing is that $f(Ar^+, B_{end})$ is quite near to the lowest Schumann frequency assignable to the oscillations of B_E serving as a candidate for a correlate for collective levels of consciousness? Could the collective effects be partially due to B_{end}? The problem is however that cyclotron period of Ar^+ is considerably shorter than the periods τ_V and τ_H associated with the oscillations of plasma balls and with the metabolic cycle.

2. What does one mean when one says that Ar^+ ions are dark? Could Ar^+ ions be dark atoms in the sense that the electron is not lost but is transformed to a dark valence electron with scaled up size of orbital proportional to n^2 [L7]. Ar^+ ion would be analogous to Rydberg atom [K19]. Dark electrons could form dark super-conductor coupling with its total charge to the electric field of the negatively charged electrode. The members of Cooper pairs could reside at parallel flux tubes connecting plastic balls with parallel or antiparallel magnetic fluxes. This could explain the synchronous oscillation of the plastic balls and also the formation of crystal-like phase.

4.1.7 Could DNS serve as the source of metabolic energy in the system studied?

The system considered requires metabolic energy. The metabolic energy would be fed to the system as it transforms to crystal-like phase and is dissipated via vertical oscillations in the force field defined by gravitational and electric fields. Unless the experimental arrangement involves a hidden energy feed, there must be present some unidentified source of metabolic energy in the system itself, that is plastic balls plus Ar^+ ion plasma.

TGD inspires the proposal that DNS generates the metabolic in pre-biotic systems, where photosynthesis need not be present yet and there is no storage of metabolic energy to biomolecules. Could something analogous to DNS take place also now?

1. If one wants to identify both f_V and f_H as cyclotron frequencies for the same value of magnetic field, one must assume that both Ar^+ and H^+ ions are

present. Therefore the formation of dark proton sequences suffering dark weak decays to dark nuclei containing neutrons becomes possible. The TGD based model [K15] [L2, L5] predicts is that the spectroscopy of dark nuclei is the same as those of ordinary ones if dark nuclear binding energy scale and neutron proton mass difference are both scaled down like $1/h_{eff}$. The occurrence of nuclear transmutations caused by dark nucleosynthesis is the basic prediction.

2. Also the fusion of Ar^+ nuclei and dark nucleon sequences is possible. The dark fusion of two Ar^+ nuclei with $(Z, A) = (18, 40)$ proceeding via formation of dark Kr nucleus consisting of two Ar^+ nuclei and transformation to ordinary Kr would produce stable Krypton isotope with $(Z, A) = (36, 80)$ liberating nuclear binding energy ~ 7.6 MeV assuming that the dark nuclear binding energy is negligible (the model predicts it to be of order of few keV). Sn isotope with $(A, Z) = (120, 50)$ is the lightest isotope with mass number $3\times 40 = 120$ of 3 Argon nuclei. This would require the transformation of 4 protons to neutrons by dark beta decay to reduce total charge 54 to 50. This process would however requires energy of 21 MeV and would therefore not occur spontaneously.

   Kr production would be a testable signature of this mechanism. Kr could end up to the negatively charged plastic ball or negative electrode. This would induce a loss of Argon from the system. Could the loss of Ar^+ and production of Kr ions be detectable?

DNS or at least the transformation of dark nuclei to ordinary ones could be a stochastic process. If this mechanism provides metabolic energy for prebiotic lifeforms, it should be able to sustain itself. There should be some signal making possible charge separation leading to the generation of dark proton sequences at flux tubes in turn leading to DNS and the generation of crystal-like phase in turn generating the cyclotron radiation.

1. A possible mechanism is suggested by Pollack effect [L1] [L1] occurring in water environment bounded by gel in the presence of suitable signal providing energy. There are several kinds of signals providing energy such as light at visible or IR frequencies or even a mechanical perturbation. What happens that water molecules, which are already in excited state near the splitting of hydrogen bond lose one proton as they absorb photon and proton becomes dark and goes to magnetic flux tube. The generation of the excited state requires UV energy of order 5 eV. Solar radiation or possibly occurring DNS events could provide the UV light.

   In the recent case water and gel phase are missing. One might however hope that the dark photons - say those with UV energies - transforming to ordinary photons could induce charge separation in BF balls or at their surface layers and transform protons to dark protons at flux tubes. If the cyclotron radiation from decaying cyclotron BE condensates corresponds to a value of Planck constants for which dark photons transform to bio-photons, this condition is satisfied. This is implied by $h_{gr} = h_{eff}$ hypothesis. If this takes place the total negative charge of plasma balls should be larger than the total charge of Ar^+ ions.

2. Could the charge separation zg the surface of plasma balls give rise to an analog of cell membrane like structure giving rise to (generalized) Josephson junctions? If so, the analogy with living cell would become even deeper. Also the flux tubes between plasma balls act as Josephson junctions making possible oscillating non-dissipating currents generating dark Josephson photons with energy $E = eV$ and frequency $f_J = eV/h_{eff}$.

4.2 Speculative connections with TGD inspired views about quantum biology and consciousness

The model for the findings has allowed to develop in more detail the basic ideas of TGD inspired quantum biology.

1. The model has led to a concrete proposal for how the MB controls BB using forced electromagnetic and mechanical oscillations at low frequencies by using the transformation of dark photons to bunches of low energy photons. Also the analogs of Alfwen waves suggest themselves as a control mechanism.

2. DNS could provide a universal pre-biotic mechanism for producing metabolic energy and the needed elements. This mechanism might be active even in the recent biology in some exceptional situations [I3]. DNS is also predicted to precede ordinary nucleosynthesis in pre-stellar evolution so that primordial metabolism would not depend on chemistry and pre-biotic and pre-stellar evolution could proceed hand-in-hand and DNS would produce heavier elements also outside the stars [L5].

   Even more, TGD based model for dark DNA identifies sequences of dark protons as analogs of DNA with sequence of 3 protons serving as analog of DNA codon. Also the dark analogs of RNA,tRNA, and amino-acids are predicted. Dark DNA sequences are dark nuclei so that the emergence of dark DNA would mean also the emergence of DNS as a basic metabolic mechanism. This would resolve the egg-or-hen problem about whether genes or metabolism came first.

3. The chemical structure of plastic balls involves aromatic 6-cycles associated also with DNA nucleotides. Both DNA and cell are negatively charged and thus analogous to the negatively charged plastic balls. Could negatively charged regions, about which the exclusion zones (EZs) of Pollack formed to water in presence of say visible light have served predecessors of cells?

4. Gel-sol transition and protein folding and unfolding are basic processes of cell biology. Could the proposed basic control mechanisms control also these processes. Could gel-sol transition and protein unfolding correspond to a melting of crystal-like structure and splitting of flux tube pairs to U-shaped flux loops or vice versa induced by a change of h_{eff}?

5. Could quantum criticality realized as a family of flux tubes with fixe L/S ratio and same energetics but with varying value of $h_{eff}/h = n$ make possible the adaptation of the dynamics of MB to the dynamics of various oscillations of BB? This would be essentially entrainment making possible both sensory

perception and motor actions. Control of mechanical processes at the level of ordinary matter would involve the decay of dark low frequency photons to n ordinary photons. Chemical control would involve transition to single ordinary photon with n-fold frequency.

This view is also supported by the realization that brain consciousness is not a continuous stream but more like a sequence of flashes (see `http://tinyurl.com/y84az3bh`). This is one of the basic predictions of TGD inspired theory of consciousness based on what I call zero energy ontology (ZEO). One can say that the sub-self (mental image) is a life-cycle of a conscious entity and that one has sequences of this kind of periods with opposite arrows of time: self dies and reincarnates with opposite arrow of time. Consciousness would have sleep-awake cycles in all time scales. This would give rise to various bio-rhythms. In EEG this would show itself as a decomposition to portions of duration of order .3 seconds.

In ZEO this could be interpreted in terms of a sequence of life cycles in which time increases in opposite directions: first at (call it) "upper" boundary of causal diamond (CD), which shifts towards geometric future, then at "lower" boundary, which shifts to geometric past, and so on... . Note that the birth at given boundary is only slightly later than the latest death at it so that also our wake-up period at level to which EEG is associated could be repeated births and reincarnations forming an approximate continuum at given boundary of CD. Also wake-up-sleep cycle could be like this. Strobing character is predicted to be a universal feature of consciousness.

In TGD inspired quantum biology the strobing character of consciousness can be related to the nature of metabolism, which does not take place as continuous feed of energy but as doses with some average rate.

To sum up, the cautious non-orthodox proposal is that the description of the finding in terms of the notions of non-equilibrium thermodynamics might not be enough. Rather, a generalization of quantum theory introducing a hierarchy of Planck constants explaining dark matter and providing a general TGD inspired model for living matter would be needed.

5 A system of particles able to self-assemble and self-heal in presence of acoustic waves

Above I told about a system of charged plastic balls above electrode with same charge of sign imbedded in plasma of positively charged Argon ions. This system exhibits life-like properties, in particular a sequence of phase transitions between crystal-like with synchronous oscillations and gas-like states. This requires a feed of metabolic energy which is not present. To my view non-equilibrium thermodynamics with stochastic resonance feeding the energy is not enough to explain the finding.

The model for the system based on TGD inspired quantum biology involves the notion of magnetic body carrying dark matter identified as $h_{eff} = n \times h$ phases; a network of magnetic flux tubes (magnetic body) controlling biological body (now charged plastic balls) and responsible for coherence and synchrony (of the crystal-like phase now); the control of the oscillations of BB by cyclotron radiation (now

the plastic ball system) resulting from decays of cyclotron condensates of charged particles (now protons and Ar ions). The source of metabolic energy would come from dark nucleosynthesis explaining nuclear transmutations occurring in living matter and "cold fusion" and serving as source of metabolic energy in prebiotic stage when the chemical energy storage had not yet emerged. Dark analogs of DNA, RNA, tRNA, and amino-acids are dark protons sequences realizing degeneracies of vertebrate genetic code are dark nuclei and can transform to ordinary nuclei and liberate nuclear binding energy so that the hen-egg question about which came first: metabolism or genetic code, is resolved: hen= egg.

Now I found a popular article "*Sound waves direct particles to self-assemble, self-heal*" (see `http://tinyurl.com/ybefq2ah`) telling about another particle system far from thermal equilibrium and exhibiting life like properties. Scientists at the Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) demonstrated how particles, floating on top of a glycerin-water solution, synchronize in response to acoustic waves blasted from a computer speaker. The article "*Emergence of an enslaved phononic bandgap in a non-equilibrium pseudo-crystal*" [D1] (see `http://tinyurl.com/ybugqjr6`) telling about the study is published in the journal Nature Materials.

In this case there is an energy feed to the system realized as a monochromatic sound wave. The system responds to an incoming sound wave and gradually the average response of the system which is in the beginning of the experiment essentially constant as function of wavelength develops a wave length gap in the response below the wave length of the incoming sound wave. The emergence of forbidden wavelengths can be interpreted as a synchronous response modellable as a reaction of damped oscillation to a driving force at resonance frequency. The video of the popular article shows how the wave length gap emerges in time scale of 45 minutes. Also the theoretical prediction for the response is given as a curve and is agrees rather nicely with the outcome.

The comment of the co-lead author Chad Ropp, a postdoctoral researcher in Zhang's group is following.

> We show that individually 'dumb' particles can self-organize far from equilibrium by dissipating energy and emerge with a collective trait that is dynamically adaptive to and reflective of their environment. In this case, the particles followed the 'beat' of a sound wave generated from a computer speaker.

To my opinion "beat" cannot however mean here what it means usually since this requires that input acoustic signal would be superposition of signals with nearly same frequencies and beat would occur with frequency which is difference of these. This unless one interprets the acoustic signal as beat signal associated with the frequency difference.

The abstract of the article gives a more technical description about what happens.

"Material systems that reside far from thermodynamic equilibrium have the potential to exhibit dynamic properties and behaviours resembling those of living organisms. Here we realize a non-equilibrium material characterized by a bandgap

whose edge is enslaved to the wavelength of an external coherent drive. The structure dynamically self-assembles into an unconventional pseudo-crystal geometry that equally distributes momentum across elements. The emergent bandgap is bestowed with lifelike properties, such as the ability to self-heal to perturbations and adapt to sudden changes in the drive. We derive an exact analytical solution for both the spatial organization and the bandgap features, revealing the mechanism for enslavement. This work presents a framework for conceiving lifelike non-equilibrium materials and emphasizes the potential for the dynamic imprinting of material properties through external degrees of freedom.

The system has energy feed as acoustic wave (from the left in the video) which gradually shifts the system to the right. Therefore the far from equilibrium thermodynamics without stochastic resonance works satisfactorily. TGD vision might provide a competing quantum description.

Also now the system involves materials appearing in living matter. Glycerin is closely related to glycerol and glycerol (see `http://tinyurl.com/p7mr2bj`) backbone appears in lipids serving as basic building bricks of cell membrane). Glycerin is dissolved in water, which is in a key role in TGD inspired quantum biology. Since I have only access to the abstract of the article, I do not know what is whether the particle are organic material too.

Can one apply the general quantum description to explain the frequency gap?

1. The metabolic energy feed is now by acoustic oscillations and should induce the phase transition generating magnetic flux tube network containing dark particles having $h_{eff} = n \times h$ responsible for the synchronous oscillations.

2. Quantum criticality at the level of the MB could make adaptation possible. The flux tubes with same ratio of L/S of length L and transversal area S scaling like $h_{eff}/h = n$ so that L/S remains invariant under scalings of h_{eff} correspond to same magnetic energy and cyclotron energies. Adaptation would mean that cyclotron frequency for BE condensate of say protons at magnetic body becomes nearly equal to the frequency of sound wave by a suitable choice of n if the value of magnetic field strength is in reasonable range: this means that flux tubes tune their length and thickness by magnetic motor actions. Note that in pseudo-crystal phase exhibiting life-like aspects it would be MB which drives rather than sound wave. Cyclotron radiation from BE condensates at MB would drive the synchronous oscillations of particles at the nodes of flux tube network performing oscillations (generalization of Alfwen waves to oscillations of flux tube analogous to string vibrations).

3. The wavelength distribution of the response evolves from an asynchronous response of the particles to acoustic wave to that corresponding to pseudo-crystal and dictated by the response of MB to acoustic wave. In the initial situation the response does not depend on λ. The response of MB affects the particle system only in a narrow band of wavelengths below $\lambda = lambda < 0$ and "freezes" it in this range.

4. The quantum model for the plastic ball system would suggests an analog of entrainment with the acoustic frequency occurring also in brain. Flux tube

network would "freeze" the acoustic oscillations of the system of balls in the wavelength gap forcing them to oscillate in phase but with reduced amplitude. The energy would go to increasing the magnetic energy of flux tubes and to Alfwen waves of MB analogous to lattice oscillations and having a wavelength band around the acoustic wavelength. Due to the "freezing" the amplitude of the oscillations becomes small in the gap. The energy distribution in the wavelength region outside the gap would not be affected.

The analogs of Alfwen waves are realized as stringy oscillations of magnetic flux tubes at MB. Alfwen waves have a wavelength band around the acoustic wavelength. The wavelength band is analogous to energy bands associated with energy levels of atoms in solids.

5. The healing of the system would mean a regeneration of the MB under metabolic energy feed. The ability to react to sudden changes in environment might be understood in terms of the ability of MB to adapt in the proposed manner. It would be interesting to see how the system reacts to the change of the acoustic frequency. The model would require change of the value of $h_{eff}/h = n$.

To sum up, essentially the same quantum model could describe both the system of plastic balls and the recent system. Now acoustic wave would serve as the source of metabolic energy and metabolic energy would be fed to MB.

6 A model for the control of biological body by magnetic body

The recent work in attempts to understand various surprising findings [I4] [D1] about very simple self-organizing systems assuming that they are actually macroscopic quantum systems at the level of magnetic body (MB) leads to a rather concrete model for how MB carrying dark matter identified as $h_{eff}/h = n$ phases controls the part of system consisting of ordinary matter - biological body (BB) in biological context. The key element is magnetic body (MB) involving flux tube network able to make $h_{eff} = n \times h$ changing phase transition changing its connectivity (the extreme corresponds to phase transition between crystal-like and plasma-like states).

The control is assumed to involve Alfwen waves with the frequencies of cyclotron transitions for the dark matter. Alfwen waves induce resonant forced oscillations of the particles at the nodes of the network. MB adapts to the dynamics of BB by using quantum criticality: if the length L and transversal area S of flux tube are scaled up by n, the ratio L/S is unaffected and the energetics of the system (cyclotron energies and the magnetic energies of the flux tubes) remains un-affected but frequencies scale by n. By a suitable choice of n system and L/S ratio MB can gain control over BB.

In the sequel this picture is tested in biological context. If MB controls basic biological processes at BB then cyclotron frequencies for biologically important ions determine the time scales of basic bio-processes involving various kinds of molecular motors. In communications from BB to MB the difference Δf_c of cyclotron

frequencies of ions associated with cell membrane at different sides of cell membrane and would determine the time scales of these communications [K10, K3, K11]. For large enough values of n membrane potential would add a small contribution $\Delta f = ZeV/h_{eff}$ to Δf_c and code nerve pulse patterns and therefore sensory information to the Josephson radiation.

6.1 The basic hypothesis

The basic hypothesis which led to the idea about hierarchy of dark matter labelled by n and having purely number theoretic interpretation in adelic physics [L8] is that the magnetic field at flux tubes has a spectrum of values. The ideas ab out the spectrum for the values of magnetic field has generalized gradually.

1. The first working hypothesis inspired by the work of Blackman [J2] was that the most important value is what I have called endogenous magnetic field $B_{end} = 2B_E/5$, where $B_E = 0.5$ Gauss is is the nominal value of the Earth's magnetic field.

2. This assumption turned however to be too restrictive. The spectrum of visible bio-photons identified as resulting in a phase transition transforming dark photons to ordinary photons with the same energy would correspond to that of magnetic fields corresponding to single octave.

3. The hypothesis that bio-photons with energy range in visible and UV assignable to molecular transition energies result from dark photons by energy conserving transition, predicts that actually several octaves are involved.

4. One can assign the spectrum of magnetic fields strengths also to the audible frequencies making in the case of humans 10 octaves. One could see the emergence of higher octaves as outcome of evolution extending gradually the repertoire of control actions performed by MB.

5. One can argue that the field strengths at MB are probably not higher than say .2 Tesla, which corresponds to $10^4 \times B_{end}$ and to 13 octaves as an upper bound for the range of magnetic fields. This gives a strong upper bound for the cyclotron frequencies. In case of proton the upper bound is $f_c(p) < 3$ MHz. For bats the range of audible frequencies extends to MHz. In the case of Fe this would correspond to $f_c(Fe^{2+}) < .1$ MHz. This gives a strong limitation on processes controllable by cyclotron radiation.

For signals from cell membrane the limits are not so strong. Suppose that generalized Josephson frequencies are responsible for the communications. Ordinary Josephson frequency equals to ZeV/h_{eff}, where $V \sim .05$ Volts is membrane potential. For small h_{eff} ordinary Josephson frequency dominates over the difference of cyclotron frequencies this allows rather high frequencies below 5×10^{12} Hz. One might argue that at this limit BB sends metabolic energy to MB. For large values of h_{eff} ordinary Josephson frequency gives only rise to a small modulation coding for nerve pulse patterns. At this limit BB would send only information to MB.

In the following the simplest hypothesis $B = B_{end}$ is taken as a starting point and applied to various situations. One can make several questions. One can consider the situation from the point of view of control of BB by MB and communications from BB to MB.

1. Control of BB by MB.

   The most important activities are control of phosphorylation of ADP to ATP using ATPase enzyme, replication and transcription of DNA, and translation. Various molecular motors such as ATPase, DNA and RNA polymerases, helicases, and various propellers (flagellas, kinesin, dynein) represent examples of bio-control.

   What could one say about the role of the control based on cyclotron radiation at the level of bio-catalysis? For instance, could one understand the time scales of DNA transcription and mRNA translation. Note that they should be nearly the same in an optimal situation so that also the corresponding cyclotron frequencies should be essentially same. Could one understand the role of cofactors - say Mg^{2+} - necessary for the action of enzymes using cyclotron radiation hypothesis?

2. Communications from BB to MB.

   If generalized Josephson radiation from the cell membrane to MB is responsible for these communications then the cyclotron frequencies for the ions assignable with nerve pulse transmission should be of key importance.

6.2 Metallic and organic cofactors

Cofactors (see `http://tinyurl.com/d6jnd49`) are necessary for the functioning of enzymes possibly realizing the bio-control by MB. They can be divided into metal ions and organic co-factors. The working hypothesis is that the cyclotron frequencies associated with co-factors coordinate the functioning of enzyme and determine the ratew of the processes involved.

It is assumed that for given oxidation state assignable to a compound also free ion with ionization state equal to the oxidation state can appear. Table 1 gives the cyclotron frequencies of metallic cofactors for their oxidation states.

For instance, the ions Mg^{2+}, Mn^{+}, Cu^{+}, appear as metallic cofactors. For$B = B_{end}$ they have cyclotron frequencies 25.0 Hz, 10.9 Hz, and 4.8 Hz ($f_c(Fe^{2+}) = 2f_c(Mn^{+})$). Note that Ca^{++} is often regarded as signalling ion rather than co-factor but that it has also important role in catalysis. A natural guess is that the cyclotron frequencies define typical rates for bio-catalytic reactions for which enzyme has metal ion as a co-factor.

There also organic cofactors having typically mass number less than 1000. This implies that cyclotron frequency is above $f_{min}0.3 \times Z$ Hz for $B = B_{end}$ if the organic cofactor has charge Z. The first guess is that also their cyclotron frequencies are important and play the same role as those of metallic cofactors. These cyclotron frequencies are considerably lower than metallic cyclotron frequencies unless the cofactor has constant charge density. DNA is a good example of molecule with

Table 1: Metallic cofactors possibly important for the control of BB by MB. A denotes atomic weight for the most stable isotope. Cyclotron frequencies are calculated for $B_{end} = .2$ Gauss.

$Metal$	A	$Oxidation\ states$	f_c/Hz
Mg	24	2	25.0
Ca	40	2	15.0
Cr	52	3	17.3
Mn	55	2	10.9
Fe	56	$(2,3)$	$(10.7, 16.0)$
Co	59	$(1,3)$	$(5.1, 15.3)$
Cu	64	1	4.7
Zn	65	2	9.2
V	51	$2, ..., 5$	$(9.2, ..., 29.4)$
Mo	96	$-2, 1, ..., 6$	$(3.1, ..., 15.7)$
Cd	112	$(1,2)$	$(2.7, 5.4)$
I	127	$(1,2,..)$	$(2.4, ...)$

Table 2: Ions possibly important for communications from BB to MB. A denotes atomic weight for the most stable isotope. The smallest cyclotron is calculated for $B_{end} = .2$ Gauss.

Ion	A	$Oxidation\ states$	f_c/Hz
Li^+	(6,7)	1	$(50.0, 42.8)$
Na^+	23	1	13.0
Cl^-	55	-1	8.6
K^+	39	1	7.7
Ca^{++}	40	(1)	15.0

constant negative charge density: the cyclotron frequencies are rather near to 1 Hz independent of the DNA sequence.

6.3 Biologically important ions assignable to the communications from BB to MB

There are also other important biological ions involved with the communications from BB to MB. Besides Ca^{2+} ion also Na^+, Cl^-, K^+ are important ions in the dynamics of nerve pulse transmission. In TGD inspired for nerve pulse and EEG the generalize Josephson frequencies for these ions are involved with the communications from brain to MB. Li^+ ion is also known to be important and too low concentration of Li^+ is known to correlate with depression and infection like state of brain.

All these frequencies are in EEG range. Li_6^+ cyclotron frequency is 50 Hz and is known to correspond to a frequency having effects on living matter. Li_7^+ cyclotron frequency is 37.5 Hz and is rather near the thalamocortical resonance frequency with

nominal value of 40 Hz.

There are bio-molecules involved with signalling inside bio-system rather than from BB to MB. First messengers consist of hormones and neurotransmitters. Second messengers couple to first messengers to overcome the cell membrane barrier (see http://tinyurl.com/yajhj9zb. An interesting question is how they relate to the communications from MB to BB: could cyclotron radiation control these communications?

I have proposed that messengers do note represent real communications but only represent the ends of the communication lines so that their transfer would generate flux tube connections between the sender and receiver. The real signal would proceed as dark photons and/or super currents along the flux tube connections. If so then MB would control communication by first and second messengers by building the communication lines unless they already exist as flux tubes.

Second messengers include also neutral gases such as NO, CO and H_2S. Hydrophobic molecules such as diacylglycerol, and phosphatidylinositols and hydrophilic molecules such as cAMP, cGMP, IP3 appear as second messengers. For instance, could control of MB be involved to the transformation of first messenger signal to second messenger signal. Note that also Ca^{2+} is second messenger.

6.4 About the role of cyclotron frequencies in the bio-control by MB

Bio-catalysis is a basic tool of bio-control and should be controlled by MB. Enzymes should involve a part making possible the control by MB, and so called cofactors (see http://tinyurl.com/d6jnd49) are excellent candidates for this part since without them enzyme does not perform its function.

In the following the cyclotron frequency hypothesis is tested for some biologically important processes assuming $B = B_{end}$. There is a web page (see http://tinyurl.com/y7aes93x) about various scales involved with the key biological processes.

I proceed from fast to slow time scales starting from ATP synthesis and proceeding via DNA related processes involving Mg^{2+} as cofactor to oxidative metabolism involving Fe^{2+}.

6.5 Molecular motors

Molecular machines (see http://tinyurl.com/h3dqauo) are divided into two categories: molecular switches, which perform control actions and molecular motors. One might regard molecular switches as higher level motors. Here is a brief summary of molecular motors.

Molecular motors (see http://tinyurl.com/y879vdel) come in several types.

1. Rotary molecular motors include F_0F_1 ATP synthase (briefly ATPase) family of proteins (see http://tinyurl.com/h23hjkn) converting the electrochemical energy in presence of a proton gradient over the cell membrane to the chemical energy of ATP (or vice versa).

   The rotary motion of the shaft of F_0F_1 rotor makes the addition of phosphates. The rotating shaft is analogous to an assembly line containing ADPs to which

phosphates are added as it rotates. The flow of protons through cell membrane pumped back through membrane using the metabolic energy from nutrients provides energy for the rotary motion and ATP. One can wonder whether this energy is provided as dark Josephson photons.

The maximal rotation frequency is 300 Hz which corresponds to the proton cyclotron frequency for $B = B_{end}$. This suggests that dark protons at either side of membrane structure could coordinate ATP synthesis. ATP serves as universal metabolic energy currency so that this mechanism would appear everywhere in bio-logy.

The rotary motor controlling flagellum can turn as fast as 300 Hz (see `http://tinyurl.com/yaoowf9l` and `http://tinyurl.com/ybotnsg4`), which suggests that proton cyclotron frequency in B_{end} determines the upper limit for the rate.

2. Polymerization motors are rather complex motors. Actin polymerization uses ATP. Microtubule polymizerization GTP uses GTP. Dynamine (see `http://tinyurl.com/ycp5t52p` is a GTPase responsible for the separation of clathrin buds from the plasma membrane.

   Actin (see `http://tinyurl.com/y9npk83f`) polymerization involves competing factors (see `http://tinyurl.com/y7hqmm72`). The rate has upper bound .3 $\mu m/s$. Actin monomer is called G-actin, and actin (micro-)filament formed from actin monomers is called F-actin. Actin monomer has mass of 41,795 proton masses and charge of -7 units (for B_{end} this would correspond to cyclotron frequency .05 Hz).

   Actin monomers are accompanied by both ATP molecule and Mg^{2+} suggesting that both cyclotron frequencies are involved with the coordination of polymerization. From the length taken by single actin monomer about 2.75 nm one can conclude that the average rate is in the range 5.5 actin monomers per second to be compared with the $f_c(Mg^{2+}) = 25$ Hz. The assumption that cyclotron frequency coordinates the process does not seem plausible.

3. Cytoskeletal motors (myosins for muscle contraction, kinesin for moving cargo along microtubules, and dynein producing axonemal beating of flagellum and moving cargo along microtubules). These rely on ATP so ATPase (dark proton cyclotron frequency) is expected to dictate the rate. These motors bind filamentous actin and are also rather complex.

6.5.1 Nuclei acid motors

There is a large variety of nucleic acid motors. Consider first motors, which do not utilize ATP.

1. DNA polymerase (see `http://tinyurl.com/y9k9k8zj`) turns single-stranded DNA to double-stranded DNA. These motors use deoxynucleoside triphosphate XTP, C= A, T, C, G. XTP transforms to XMP by dropping diphosphate and XMP is attached to the growing DNA strand. Note that ATP gives only P to the acceptor molecule.

One can distinguish between two rates.

(a) The average DNA polymerase requires about one second to locate and bind to a primer/template junction. Once it is bound, a non-processive DNA polymerase adds nucleotides at a rate of one nucleotide per second. Interestingly, the cyclotron frequency of DNA sequence in B_{end} is near 1 Hz irrespective of the length.

(b) Processive DNA polymerases works much faster since single catalytic event adds large number of nucleotides to the polymer. The rate of processive polymerization at 37 °C is 749 nucleotides per second and corresponds to about 250 codons per second. This suggests that the rate of processive polymerization is determined by ATPase driven at proton cyclotron frequency of 300 Hz.

2. RNA polymerase (see `http://tinyurl.com/y982vb46`) catalyzes the transcription of DNA to RNA (see `http://tinyurl.com/ydaosrhg`). The basic mechanism might be though to be similar to that of DNA polymerase but the structure of these molecules is different. RNA polymerization is also 20 times slower that than DNA polymerization in E. Coli suggesting that cyclotron frequency of Mg^{++} ions, which are indeed involved, determines the rate.

   The averate rate for DNA transcription and RNA translation has upper limit of 24 codons per second and could naturally correspond to the cyclotron frequency 25 Hz of Mg^{2+} for $B = B_{end}$ appearing as cofactor in the catalyst.

3. DNA helicases (see `http://tinyurl.com/y8h3jsq2`) separate double strands of nucleic acids prior to transcription or replication. DNA replication, transcription, translation, recombination, DNA repair, and ribosome bio-genesis utilize DNA helicase. DNA strand is known to rotate during the transcription.

   If the rotation is in a direction opposite to the twisting of DNA strand, the DNA strand could open if helicase simply fixes the position part of DNA codon at which the transcription begins. Since the strands are twisted in opposite directions, this mechanism requires that the transcription takes in opposite directions for the complementary strands: this is indeed known to be the case. The average rate of opening is about 20 codons per second and opening of the strand. The rate of opening could thus be determined by the RNA polymerase having Mg^{++} as cofactor.

   Using quantum classical correspondence (QCI) the classical angular momentum assignable to the rotation of DNA can be estimated to be

$$\frac{L}{\hbar} \sim 2\pi N\langle A\rangle \frac{d^2 \times f}{L_p} \sim 172 \times N \ .$$

   Here N is the number of rotating nucleotides,$\langle A\rangle \sim 300$ is the average weight of DNA nucleotide, $d \sim 1$ nm is the radius of the helix, $L_p = m_p/\hbar$ is proton Compton length, and $f \sim 20$ Hz is the estimate for the rotation frequency.

(a) If $h_{eff}/h = n$ serves as a unit of quantized angular momentum (thish need not be the case for ordinary DNA as opposed to the dark analog of DNA for which the states 3 dark protons define a realization of DNA codons) an upper bound $n < n_{max} \sim 172 \times N$ emerges from the condition $L/\hbar_{eff} = 1$. The interpretation of dark DNA as dark nuclei gives the estimate $h_{eff}/h = d/L_p \sim 2^{20} \simeq 10^6$ the radius of nucleus. This would require $N \sim 10^4$.

(b) Another manner to satisfy the stronger quantization condition is to assume that the semiclassical quantization condition is satisfied for the system consisting of *both* ordinary and dark DNA. The simplest manner to satisfy the condition is that the angular momenta of ordinary and dark DNA are opposite and in this case be smaller than $\hbar_{eff}$. This condition would be rather natural since there would be no need to bring angular momentum to the system from outside by applying torque. Energy is however needed to break up the hydrogen bonds between strands.

There are also nucleic acid motors utilizing ATP and deserve to be listed.

1. Topoisomerase reduces supercoiling of DNA in the cell.
2. RSC and SWI/SNF complexes remodel chromatin in eukaryotic cells.
3. SMC proteins are responsible for chromosome condensation in eukaryotic cells.
4. Viral DNA packing motors inject viral genomic DNA into capsids.

Also ribosome (see `http://tinyurl.com/yacy6m3h` and `http://tinyurl.com/ybfqa423`) is a molecular motor. For some reason the list of Wikipedia article (see `http://tinyurl.com/y879vdel`) does not include it. The rate of translation is in good approximation the same as the rate of transcription as it indeed must be to make the process effective and Mg^{2+} cyclotron frequency might determine the rate.

For all motors involving ATP cyclotron frequency of proton is involved but and poses only upper limit for the rate.

6.5.2 The possible role of Mg^{2+} in RNA translation

Transcription and translation both occur on the time scale of 1 minute for a protein of typical length (see `http://tinyurl.com/ycm5uur9`). However, longer transcripts and bigger proteins take proportionally longer to make: this probably due to the additional operations involved. The largest protein in the human body is titin. It would take approximately an hour to translate its $\sim$ 30,000 amino acids, which makes 8 amino-acids per second. If DNA codons are transcribed with the same average rate than amino-acids are translated (synchrony), transcription rate is 24 nucleotides per second. This happens to be rather near to $f_c(Mg^{2+}) = 25Hz$ to letter.

The estimates for the translation rate however vary. Probably this is due to the definition used and the organism in question. For E. Choli the average translation rate is reported to be roughly 20 aa per second (see `http://tinyurl.com/`

ycm5uur9). For synchrony this would correspond to 60 nt/s in DNA transcription. The actual transcription rate is 40-80 nt/s for nucleotide and gives 60 nt/s on the average.

Note that the range for the rate corresponds to octave. If cyclotron radiation coordinates the process, the variation could be due to variation of magnetic field strength by octave. For DNA codon the rate would be in range $[13.35 - 26.7]$ codons per second. This could correspond to Mg^{2+} cyclotron frequency in B_{end} assignable to co-enzyme Mg^{2+} (see http://tinyurl.com/d6jnd49).

6.5.3 Translational motion and propeller mechanism

Molecular propellers (see http://tinyurl.com/y7ftgzuk) can be rotated by molecular motors that can be driven by chemical, biological, optical and electrical means or various ratchet-like mechanisms. Biological propellers are therefore only a special case. In the case of biological propellers interaction with the medium and dissipation are involved and transform rotational motion to linear motion. Medium or substrate structure such as medium or microtubule receives the recoil angular momentum.

Biology involves a large number of highly sophisticated molecular motors, such as myosin, kinesin, and ATP synthase based on propeller mechanism. For example, rotary molecular motors attached to protein-based tails called flagella can propel bacteria (see http://tinyurl.com/y83939x7). In this case the rotation frequency has 300 Hz, which suggests that ATPase and dark protons in magnetic field B_{end} with it determines the rate.

Second example is kinesin moving linearly along microtubule (see http://tinyurl.com/o4glesu). Also kinesin can be regarded as ATPase. The linear motion supports several functions such as mitosis, meiosis and transport of molecules along axon. The linear motion takes place in discrete steps of length 8 nm (cell membrane thickness is about 10 nm).

One can raise several questions related to the possible role of MB. How the energy and angular momentum are transmitted to the propeller? Could dark cyclotron BE condensates analogous to magnets be formed? For cyclotron BE condensates spin would be replaced with orbital angular momentum for the dark ions rotating at flux wall: this could give rise to large angular momentum. Could the generation of cyclotron BE condensate and angular momentum at magnetic flux wall give rise to opposite angular momenta at the propeller as a recoil effect: could this quantum phase transition happen by the exchange of polarized cyclotron photons. Does ATP provide the metabolic energy needed to build the cyclotron BE condensate in turn giving part of its energy for the propeller.

6.6 Oxidative metabolism, red cells, the fundamental bio-rhythm, and iron

Understanding the possible role of cyclotron radiation in the coordination and control of cellular respiration (see http://tinyurl.com/pkfup3g) is a further natural challenge.

1. The basic guidelines are the interpretation of "high energy" bonds as containing dark electrons $h_{eff}/h = n$ larger than for normal atoms. Also dark

protons must be present when the molecule containing dark electrons is neutral. Metabolism could be basically transfer of dark protons and electrons from the nutrients possibly reducing gradually the value of n and gradually sharing the liberated energy. The energy would go to the pumping of protons through the cell membrane and be eventually transferred to high energy phosphate bond in ADP $\rightarrow$ ATP process in ATPase as protons flow back through the membrane.

2. In oxidative metabolism O_2 is used as oxidizing agent. O_2 molecules are transferred from respiratory organs to the rest of the body using hemoglobin (see `http://tinyurl.com/ya5kyv6u`) as a carrer. Oxygens atoms are bound to the heme part of the hemoglobin containing Fe^{2+} ion. O_2 binds to Fe^{2+} and oxidizes it so that one temporarily obtains Fe^{3+} ion and O_2^- (superoxide) ions.

   Concerning cyclotron frequencies, what puts bells ringing is that both $f_c(Fe^2) =$ 10.7 Hz, $f_c(O_2^-) = 9.7$ Hz are in alpha band and near to the fundamental biorhythm with frequency 10 Hz: could the fundamental bio-rhythm be seen as a direct signature of the role of MB in metabolism? $f_c(Fe^{3+}) = 16.0$ Hz is in beta band. $f_c(Fe^{3+}O_2^-) = 6.8$ Hz makes sense at least formally and is in theta band. One can of course ask whether it is possible to regard Fe^{3+} ion and O_2^- ions as independent, possibly dark, cyclotron states. If the electrons involved are dark this might make sense.

3. In an-aerobic respiration (see `http://tinyurl.com/m955wzb`) sulfate (SO_4^2, $f_c = 6.3$ Hz), nitrate (NO_3, $f_c = 6.3$ Hz), sulphur (S,$f_c = 9.4$ Hz), or fumarate ($HO_2CCH{=}CHCO_2H$) are used instead of oxygen. Interestingly, the cyclotron frequencies for sulfate and nitrate are very near to each other and for sulphur ion the cyclotron frequency is also in alpha band.

Cellular respiration converts biochemical energy from nutrients - carbohydrates, amino-acids, fats - into energy carried by ATP and then releases the waste products such as CO_2 and H_2O. The reactions include catabolic reactions breaking down the large molecules to smaller ones, releasing energy in the process as weak "high-energy" bonds are replaced by stronger bonds in the products. Cellular respiration can be seen as a combustion reaction - burning of nutrients.

The most common oxidizing agent (electron acceptor) is molecular hydrogen O_2: in this case one talks about oxidative metabolism or aerobic respiration. The energy of ATP in "high-energy" phosphate bond drives biosynthesis, locomotion or transportation of molecules across cell membranes.

Aerobic respiration is the preferred method of pyruvate (CH_3COCOO, see `http://tinyurl.com/yadb3fsn`) breakdown in glycolysis. Pyruvate contains two O= bonds reduced to O- type bonds in the process producing CO_2 and water. Pyruvate enters to mitochondria and is fully oxidized by the Krebs cycle (see `http://tinyurl.com/p6599hq`) also known as tricarboxylic cycle or citric acid cycle.

1. Krebs cycle produces NADH (nicotin-amide-adenine-dinuclotide containing two adenines and two phosphates, see `http://tinyurl.com/mcodgjs`)) carrying metabolic energy in "high energy" bonds.

(a) Coenzyme CoA (see http://tinyurl.com/ydbvd5q4) in acetyl-CoA (see http://tinyurl.com/z6fc4zc) brings the acetyl group CH_3 (see http://tinyurl.com/y74cyyqk) and metabolic energy from the nutrient to the Krebs cycle.

(b) The metabolic energy from the nutrients is associated with high energy thioester bond at the ened of acetyl-CoA in which C has bonds of type CH_3- and O= and S-. Sulphur belongs to coenzyme CoA involving phospho-adenosine and di-phosphate.

2. The NADH produced by Krebs cycle carrying the metabolic energy is received by the electron transport chain (see http://tinyurl.com/hxwb6ay) performing oxidative phosphorylation (see http://tinyurl.com/yacue4an) transforming ADP to ATP. NADH is oxidized to NAD^+ and is returned back to the Krebs cycle.

   Electron transport chain is needed to transfer the electrons from donors to acceptors and to extract the energy of electrons and use it to the pump of protons trough the inner membrane. Electron transport chain involves as the first step the process NADH $\rightarrow NAD^+ + H^+ + 2e^-$ producing protons and electrons. This happens inside the inner membrane of mitochondria. Electrons and protons are then transported through the inner membrane to the inter-membrane space using co-enzyme Q(10) (see http://tinyurl.com/y9tosfzc) as a carrier. Electrons are transported further with the help of cytochrome c (see http://tinyurl.com/ybkb7dbu), which is soluble to water.

   (a) Ubiquinone enzyme Q takes care of the transfer of protons and electrons through the inner membrane to the inter-membrane space. Q receives two protons and electrons and is reduced to QH_2 at the inner side of the membrane. QH_2 oxidizes back to Q at the outer side of the membrane and therefore shuttles the protons through the membrane.

   (b) In the inter-membrane space of mitochondria (having double membrane) electrons are transferred along a chain of water cytochrome c (see http://tinyurl.com/ybkb7dbu) molecules forming a kind of ladder along which electrons move down. At given step Fe receives the electron and then gives it to the next cytochrome c molecule. At the bottom of the chain electrons with lowered energy are given to oxygen molecules in oxidative phosphorylation of ADP by ATPase.

3. Free radicals having one or more unpaired valence electrons appear as side products of the process. The working hypothesis is that paired valence electrons have non-standard value of $h_{eff}/h = n$ and unpaired ones have the standard value being highly reactive. Peroxides, superoxide (O_2^+), hydroxyl radical OH, and singlet oxygen (O) are free radicals having negative biological effects. O_2 molecule is di-radical but in its ground state has parallel unpaired spins and is stable: in combustion it transforms to unstable and highly reactive spin single state with paired spins.

6.7 Model for RNA life

There is to a very interesting paper about the possible mechanism giving life-like properties to RNA system during the conjectured RNA era [I2] (see `http://tinyurl.com/ydhr3qnq`). The title of the article is "*The life story of hydrogen peroxide II: a periodic pH and thermochemical drive for the RNA world*". "Life-like" would mean "breathing" realized as these oscillations and would require a metabolic energy source.

I try to interpret the proposal on basis of my own model [L6] bringing in the control of chemistry by magnetic body (MB). The idea is that MB adapts to the chemical dynamics and gets a control over it by driving forces realized in terms of dark cyclotron radiation form MB resonating with the chemical oscillations. "Breathing" would basically correspond to the periodic formation of flux tube network with high connectivity giving rise to crystal-like or gel-like state and subsequent decay to plasma-like state with low connectivity and would require metabolic energy feed.

1. The periodic drive is central in TGD based model and gives rise to the "breathing". Metabolic energy feed must be involved. In the model for life-like properties of plastic ball system it would be dark nucleosynthesis. In another experimental system acoustic wave feeds energy to the magnetic body (MB). It is said that the peroxide ($H-O-O-H$) bond between oxygens would be the source of the metabolic energy. Peroxide - usually regarded as a mere nuisance (highly Reactive Oxygen Species causing biological damage) - would serve as the "food" of the system. This is the new and radical idea. According to the article, the primary energy source would be solar or geothermal. In TGD one can consider dark nucleosynthesis preceding ordinary nucleosynthesis as the source (it might have even given rise to Fe in the core of Earth!).

2. Figure 1 in the article illustrates that peroxide H_2O_2 would produce in presence of $S_2O_3^{-2}$ or $S_2O_3^{-1}$ thermal and pH oscillations: "breathing". Peroxide is also told to produce oxidized sulfur species and oxidixe RNA nucleotides: this would liberate metabolic energy in RNA? The outcome would be the replication of RNA. Oxidation of thiosulfate ion by H_2O_2 mentioned in the abstract would naively mean that $S_2O_3^{-2}$ gives 1 or 2 electrons to H_2O_2. Table 1 listing various reactions involved in oxidation is however rather complex. It begin to accept that I will never really understand what chemists mean with oxidation! In any case, also the oxidation reaction can happen in several steps.

Consider next the situation from quantum TGD point of view.

1. Periodic oxidation would correspond to breathing generating repeatedly connected magnetic body with quantum coherence and larger h_{eff} - following the model for breathing plastic ball system as periodic formation of crystal-like and plasma-like states.

2. Cyclotron radiation from cyclotron condensates of some important ions would serve as clocks - breathing in several time scales. What are these ions? In plastic ball system protons and Argon ions. 300 Hz is the frequency for $B = B_{end} = .2$ Gauss and also the rate of ATP:s produced by ATPase: of course,

it was not present at that time. Thiosulfate cyclotron frequency would be 5.4 Hz in B_{end} for charge of -2 units.

The chemical oscillation periods emerging in the model of authors are measured in fraction of hour whereas the cyclotron periods for ions are fractions of second for ions for $B = B_{end}$. Therefore the strength of the magnetic field is much lower than that of Earth. Intergalactic magnetic fields are of order nanoTesla and this would bring scale factor of about 10^4 to cyclotron periods and they would be of same order of magnitude as the time scales coming from chemical kinetics. For proton the cyclotron period would be 33 seconds. For $S_2O_3^{-2}$ cyclotron time scale would be scaled up by the atomic weight 112 giving roughly 40 minutes. This suggests that RNA era occurred in intergalactic space if it occurred at all. If it continues in recent biology, the dark matter must reside at the flux tubes of intergalactic magnetic field. This does not make sense in Maxwell's theory but makes sense in the many-sheeted spacetime of TGD Universe.

3. pH oscillation means that at least dark protons would be involved. pH could be quite generally a direct measure for the density of dark protons. The density of dark protons oscillating periodically meaning formation of cyclotron condensate and its decay could correspond to oscillating pH.

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