Life-like properties observed in a very simple system

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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 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.

TGD provides a general model for living systems relying on the notion of magnetic body (MB), hierarchy of Planck constant $h_{eff} = n \times h$ labelling phases of ordinary matter identifiable as dark matter, and the realization of control and communication between MB and biological body using dark photons. 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.

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. 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. 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.

Contents

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 [I3] (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 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.

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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.

2 Experimental findings

The news [I3] 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 [D1]. 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 [L7, L8] 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 subsystems 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 $E_c = h_{eff}$ 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. Biophotons 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 biochemistry 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 reconnecting 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 reconnection 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 nuclei 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 [I3] 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 superfluids 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 [I3] 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 piezo-electrets 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

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

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

$$f_c(membrane) = 3c \times a^2 \times \frac{a}{d} \times f_c(proton, B_{end}) \times \frac{Coulomb}{e} \times \frac{V}{Volt} = 1.5 \times 10^{-7} \times \frac{10\mu m}{d} \times \frac{B}{B_{end}} \times \frac{V}{.05 \ Volt} \ Hz \ .$$

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 [L6]. 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 quantum biology

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 [I2]. 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.

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.

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