Summary of TGD Inspired Ideas about Free Energy

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Abstract

A summary of the work done in an attempt to understand free energy phenomena in TGD framework is provided: this includes some slightly updated chapters from the book "p-Adic length scale hypothesis and dark matter hierarchy". Some new ideas ideas and devices related to free energy are discussed.

The ZPE approach is compared with the TGD approach identifying dark matter as a hierarchy of phases of ordinary matter characterized by non-standard value of Planck constant $h_{eff} = nh$. The general ideas behind anomalous hydrolysis of water are introduced, and a TGD inspired model for Brown's gas explaining its anomalous properties is formulated. This inspires a vision about how metabolism in living matter could utilize the mechanisms explaining the behavior of Brown's gas.

1 Introduction

The study of free energy phenomena has evolved to the level at which commercial applications are seriously developed despite the refusal of main stream science to admit the reality of these phenomena. TGD predicts numerous new physics phenomena. These might explain the claimed free energy phenomena such as over unity energy production without identifiable energy source in electrolysis of water, the strange properties of Brown's gas resulting in this process and the claimed cold fusion associated with electrolysis and also the energy production in sonoluminescence claimed to be due to cold fusion reactions. Second class of strange phenomena relate to rotating magnetic systems with Yildiz magnetic motor being the most dramatic example in this respect.

The first sections represent a summary about TGD views concerning cold fusion and related topics: the material comes from three chapters of the online book "p-Adic length scale hypothesis and dark matter hierarchy" [K16]. The summary demonstrates the evolution of ideas occurred during roughly two decades and thus reflects also the evolution of TGD.

The input from the chapters [K21] and [K15] represents the development of what I have christened nuclear string model. This model relies on the fractally natural assumption that atomic nuclei are analogous to proteins in the sense that they correspond to highly folded string like objects (possibly several of them) consisting of sequences of nucleons connected by color bonds having quark and antiquark at their ends. If the color bonds are neutral one obtains the counterparts of ordinary nuclei. The input from chapter [K8] includes discussion of Rossi's reactor and the reported selection rules and section about sonoluminescence.

Color bonds can also have charge ± 1 corresponding to $u\overline{d}$ and $d\overline{u}$ type quark pairs. This predicts large number of exotic nuclei. The guess for the energy scale of the exotic excitations of ordinary nuclei is around keV from an explanation for the finding that X rays from Sun induces effective variation in the rates of nuclear reaction rates: the variation would be explained in terms of excitations of creating exotic nuclei which cannot be distinguished from ordinary nuclei chemically.

Exotic nuclei represent new nuclear physics and this raises the question about their relevance for low energy nuclear reactions.

1. Could cold fusion involve a mechanism generating exotic nuclei by generating charged color bonds and in this manner help to get rid of Coulomb wall? Dark variant of weak interactions are necessary to achieve this since otherwise the rates are extremely low. Since W boson is effectively massless below the scaled up weak length scale, which should be of the order of atomic length scale, weak interaction rate would be enhanced so that they are of same order of magnitude as for electromagnetic interactions. Clearly rather large value of $h_{eff} \sim 10^7 h$ is required.

   For instance, could the exchange of a dark variant of W^+ boson between incoming proton and target nucleus (say D) transform dark proton to dark neutron and increase the charge of target nucleus by one unit (say transforming it to pseudo Helium isotope with charge 2). This would eliminate Coulomb wall and might relate to the fact that neutrons and gamma rays are not emitted in H-D cold fusion. Dark W^+ could also be exchanged between electron and p inside D and neutralize D to effective di-neutron state.

2. Could the nuclei resulting from the low energy nuclear reactions be also exotic? This would help to explain the non-standard selection rules.

Second mechanism relies on darkness alone. If incoming proton and its quarks are dark having Compton size scale of order atomic size, the target nucleus would be much smaller than quarks and one can imagine target nucleus enters the Coulomb field of negatively charged n-quark so that Coulomb wall changes sign and the reaction can proceed.

In this chapter I represent first earlier ideas and models related to free energy and after than some new material is discussed.

1. The topics from [K21] represents a vision about cold fusion based on Trojan horse mechanism allowing to circumvent Coulomb wall. All mechanisms discussed later are variants of this mechanisms.

2. The topics from [K15] contains a lot of material. For instance, included are a discussion of findings of Kanarev and Mizuno related to electrolysis of water, the $H_{1.5}O$ anomaly of water suggesting that water contains dark component, a discussion of a model of electrolysis and plasma-electrolysis, and a short discussion of the biological transmutations. The possibility of cold fusion in interstellar space could produce heavy elements so that solar interior would not be the only place where they are produced during the cosmic evolution. For instance, the well-known Lithium anomaly of cosmology could be explained in terms of cold fusion. Besides producing energy cold fusion could also make possible both spontaneous and artificially induced generation of metals and other heavier elements from light ones.

   The basic new physics element in TGD based model of electrolysis is the phase transition increasing the value of h_{eff} for the space-time sheet at which water is topologically condensed and inducing "electric expansion of water". This would occur in strong local electric fields inducing di-electric breakdown. The reversal of this phase transition would explain the observed spontaneous implosion. The third phase transition would reduce h_{eff} but increase p-adic prime p in such a manner that volume remains unaffected. This phase transition liberates zero point kinetic energy (ZPKE). This energy could be behind several anomalies related to the electrolysis of water and also provide basic mechanism of the liberation of metabolic energy in living matter. The reverse transition could be induced by irradiation by light and could take place routinely in photosynthesis and be part of ADP-ATP transition.

   Strong local electric fields would induce the h_{eff} increasing phase transitions and these fields indeed are present being associated with rough electrode surfaces. Strong electric fields appear also in cell membranes and in plasmoids proposed to define prebiotic life forms in TGD Universe. Lightnings and ball lightnings would be examples of plasmoids generating their metabolic energy by the proposed phase transition.

3. The input from [K8] includes discussion of Rossi's reactor and the reported selection rules and section about sonoluminescence with slight updatings. Also a model for the hydrino atom of Rossi based on so called q-Laguerre equation is discussed.

In last sections some new ideas and devices related to free energy are discussed. The ZPE approach is compared with the TGD approach identifying dark matter as a hierarchy of phases of ordinary matter characterized by non-standard value of Planck constant $h_{eff} = nh$. The general ideas behind anomalous hydrolysis of water are introduced, and a possible model for Brown's gas explaining its anomalous properties is formulated. This inspires a vision about how metabolism in living matter could utilize the mechanisms explaining the behavior of Brown's gas. Also cold fusion and sonoluminescence are briefly discussed with references to a more extensive summary about TGD inspired vision about these phenomena. The last section is devoted to Yildiz magnetic motor and relates closely to the model for rotating magnetic systems [K1] devices to explain the claims of Godin and Roschin [H4].

The material represents a development of ideas and TGD itself. Experimental data allow to consider several options so that a complete internal consistency of the ideas discussed is too much to hope for.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. There are concept maps about topics related to the contents of the chapter prepared using CMAP realized as html files. Links to all CMAP files can be found at `http://tgdtheory.fi/cmaphtml.html` [L1]. Pdf representation of same files serving as a kind of glossary can be found at `http:`

//tgdtheory.fi/tgdglossary.pdf [L2]. The topics relevant to this chapter are given by the following list.

- Magnetic body [L4]
- Hierarchy of Planck constants [L3]
- Pollack's observations [L5]

2 Cold Fusion And Trojan Horse Mechanism

The model for cold fusion has developed gradually as the understanding of quantum TGD and many-sheeted space-time has developed. Trojan horse mechanism has served as the connecting thread between various models. The last step of progress relates to the new vision about nuclear physics but it is still impossible to fix the model completely unless one poses the condition of minimality and the requirement that single mechanism is behind various anomalies.

2.1 Exotic Quarks And Charged Color Bonds As A Common Denominator Of Anomalous Phenomena

There should exist a common denominator for anomalous behavior of water, cold fusion, the findings of Ditmire suggesting cold fusion, sono-fusion, exotic chemistries, strange properties of living matter including chiral selection, and also phenomena like low compressibility of condensed matter which standard physicist would not be worried about.

It seems that compression inducing the generation of charged color bonds between nucleons and leading to a formation of super-nuclei with atomic distances between building blocks might be the sought for common denominator. For super nuclei the repulsive weak interactions between exotic quark and anti-quark belonging to the two bonded nuclei would compensate the attractive color force so that a stable configuration of atomic size would result. Note that the weak coupling strength would be actually strong by the general criterion for transition to the large $\hbar$ phase.

The charging of color bonds would occur via W boson exchange between exotic and valence quarks with exotic W boson transforming to ordinary W via mixing.

The alternative option is a phase transition of nuclei transforming $k = 113$ em space-time sheets of valence quarks to em dark space-time sheets with a large value of $\hbar$ suggested for heavier nuclei by the general criteria. This phase transition could be avoided if the criticality forces surplus protons to transfer the electromagnetic charge of valence quarks to color bonds so that the situation reduces to the first option. In this picture standard nuclear physics would remain almost untouched and nothing new expect exotic quarks and charged color bonds is introduced.

The following examples suggest that this general picture indeed might unify a large class of phenomena.

1. The super-nuclei formed by the dark protons of water would be a basic example about this phenomenon. The occurrence of the process is plausible if also nucleons possess or can generate closed loops with exotic quark and anti-quark at the ends of the loop belonging to the same nucleon. The fact that these protons are dark with respect to electromagnetic interactions suggests that the charge of protons is transferred to the color bonds so that the outcome is a nuclear string formed from neutrons connected by positively charged color bonds. Darkness with respect to weak interactions suggests that valence quarks are doubly dark. This would mean that the p-adic length scale of color bonds would correspond to $k_{eff} = 107 + 2 \times 22 = 151$ for $\hbar_s = n^2\hbar/v_0^2$, $n = 1$. This corresponds to the thickness of cell membrane so that the structure of water would contain information about the basic biological length scale.

2. In condensed matter the super-nuclei would form at some critical pressure when weakly charged color bonds between neighboring nuclei become possible and compensate the attractive color force. This would explain the low compressibility of condensed matter.

3. Bio-polymers in vivo might correspond to super-nuclei connected by charged color bonds whose weak charges would explain the large parity breaking involve with chiral selection. Hydrogen bond might be a basic example of a charged color bond. It could be that the value of integer n in $\hbar_s = n\hbar/v_0$ is $n = 3$ in living matter and $n = 1$ in ordinary condensed matter.

   Trojan horse mechanism might work also at the level of chemistry making possible to circumvent electronic Coulomb wall and might be an essential characteristic of the catalytic action. Note that Pd is also a powerful catalyst. $n = 1$ might however distinguish it from bio-catalysts. In separate context I have dubbed this mechanism as "Houdini effect".

   The reported occurrence of nuclear transmutations [C11, C25] such as $^{23}Na +^{16} O \rightarrow^{39} K$ in living matter allowing growing cells to regenerate elements K, Mg, Ca, or Fe, could be understood as fusion of neighboring nuclei connected by charged color bond which becomes neutral by W emission so that collapse to single nucleus results in absence of the repulsive weak force. Perhaps it is someday possible to produce metabolic energy by bio-fusion or perhaps Nature has already discovered the trick!

4. In cold fusion the nuclei of target D and Pd would combine to form super-nuclei connected by charged color bonds. This would explain why the heavy loading of Pd nuclei with D (for a review of loading process see [C12]) does not generate enormous pressures. Cold fusion would occur in some critical interval of loadings allowing ordinary and exotic nuclei to transform to each other. The transfer of the em charge of D to the color bond connecting D and Pd would make D effectively nn state. Together with the fact that the color bond would have length of order atomic radius would mean that the Coulomb wall of Pd and D is not felt by beam nuclei and Trojan horse mechanism would become possible. The prediction is that Coulomb wall disappears only only when deuterium or tritium target is used. If nuclei can transform to dark em phase cold fusion could occur for arbitrary target nuclei. That it is observed only for D and possibly H does not support this option.

   If valence quarks are doubly dark, their magnetic bodies have size of order $L(151) = 10$ nm, which is also the size scale of the nano-scaled Pd particles, color force would become long ranged. In sono-luminescence and son-fusion and also in nuclear transmutations similar formation of super-nuclei would occur and the collapse of super-nucleus to single nucleus could occur by the proposed mechanism.

5. In the experiments of Ditmire *et al* laser pulse induces very dense phase of Xenon atoms having $Z = 54$ which is heated to energies in which electron energies extend to MeV region and expands rapidly. $Z = 54$ means that Xe satisfies the most stringent condition of criticality for the transition to electromagnetic large $\hbar$ phase. This transition does not occur if protons feed the surplus em charge to the color bonds so that Xe nuclei also weakly charged. Assume that some fraction of Xe is in this kind of phase. The compression of Xe gas by laser pulse compresses Xe super-nuclei. If the connecting charged color bonds emit their em and weak charge by emission of W boson the super-nuclei collapse to single nucleus and nuclear fusion reactions become possible. The repulsive weak force becoming manifest in the compression generates brehmstrahlung heating the system and induces a violent explosion much like in sono-fusion.

In the sequel the experiments Ditmire *et al* and cold fusion are discussed in detail using this model.

3 Cold Fusion, Plasma Electrolysis, Biological Transmutations,And Burning Salt Water

The article of Kanarev and Mizuno [D11] reports findings supporting the occurrence of cold fusion in NaOH and KOH hydrolysis. The situation is different from standard cold fusion where heavy water D_2O is used instead of H_2O.

One can understand the cold fusion reactions reported by Mizuno as nuclear reactions in which part of what I call dark proton string having negatively charged color bonds (essentially a zoomed up variant of ordinary nucleus with large Planck constant) suffers a phase transition to ordinary matter and experiences ordinary strong interactions with the nuclei at the catode. In the simplest

model the final state would contain only ordinary nuclear matter. The generation of plasma in plasma electrolysis can be seen as a process analogous to the positive feedback loop in ordinary nuclear reactions.

Rather encouragingly, the model allows to understand also deuterium cold fusion and leads to a solution of several other anomalies.

1. The so called lithium problem of cosmology (the observed abundance of lithium is by a factor 2.5 lower than predicted by standard cosmology [E3]) can be resolved if lithium nuclei transform partially to dark lithium nuclei.

2. The so called $H_{1.5}O$ anomaly of water [D13, D10, D15, D9] can be understood if 1/4 of protons of water forms dark lithium nuclei or heavier dark nuclei formed as sequences of these just as ordinary nuclei are constructed as sequences of ^4He and lighter nuclei in nuclear string model. The results force to consider the possibility that nuclear isotopes unstable as ordinary matter can be stable dark matter.

3. The mysterious behavior burning salt water [D1] can be also understood in the same framework.

4. The model explains the nuclear transmutations observed in Kanarev's plasma electrolysis. Intriguingly, several biologically important ions belong to the reaction products in the case of NaOH electrolysis. This raises the question whether cold nuclear reactions occur in living matter and are responsible for generation of biologically most important ions.

3.1 The Data

3.1.1 Findings of Kanarev

Kanarev has found that the volume of produced H_2 and O_2 gases is much larger than the volume resulting in the electrolysis of the water used in the process. If one knows the values of p and T one can estimate the volumes of H_2 and O_2 using the equation of state $V = nT/p$ of ideal gas. This gives

$$V(H_2;p,T) = \frac{A(H_2)}{A(H_2O)} \times \frac{M(H_20)}{m_p} = \frac{1}{9}\frac{M(H_20)}{m_p} \times \frac{T}{p} \ .$$

Here $M(H_20)$ is the total mass of the water (.272 kg for KOH and.445 kg for NaOH).

In the situation considered one should be able to produce from one liter of water 1220 liters of hydrogen and 622 liters of oxygen giving

$$V(H_2)/V(H_2O) = 1.220 \times 10^3 \ , \qquad V(O_2)/V(H_2O) = .622 \times 10^3 \ ,$$

$$r(gas) = V(H_2 + O_2)/V(H_2O) = 1.844 \times 10^3 \ , \quad V(H_2)/V(O_2)) \simeq 1.96 \ .$$

$V(H_2)/V(O_2) \simeq 1.96$ is 4 per cent smaller than the prediction $V(H_2)/V(O_2) = 2$ of the ideal gas approximation.

The volumes of O_2 and H_2 are not reported separately. The table gives the total volumes of gas produced and ratios to the volume of water used.

3.1.2 Findings of Mizuno

Mizuno in turn found that the Fe catode contains Si, K, Cr, Fe, Cu for both KOH and NaOH electrolysis and in case of NaOH also Al, Sl, Ca. The fraction of these nuclei is of order one per cent. **Table 2** gives the fractions for both KOH and NaOH.

The results supports the view that nuclear reactions involving new nuclear physics are involved and that part of H_2 and O_2 could be produced by nuclear reactions at the catode.

1. For Si, K, Cr, Fe, and Cu the mechanism could be common for both $NaOH$ and KOH electrolysis and presumably involve fission of Fe nuclei. The percent of K in KOH is considerably larger than in $NaOH$ case and this is presumably due to the absorption of K^+ ions by the catode.

Table 1: The weight of water used in the electrolysis and the total volume of gas produced for KOH and NaOH electrolysis. $r(gas)$ denotes the naive prediction for the total volume of gas per water volume appearing in previous table. For KOH *resp.* NaOH the volume ratio $[V(gas)/V(H_2O)]$ is by a factor $r = 17.4$ *resp.* $r = 15.2$ higher than the naive estimate.

	$M(H_2O)/kg$	$V(gas)/m^3$	$\frac{V(gas)}{V(H_2O)}$	$\frac{[V(gas)/V(H_2O)]}{r(gas)}$
KOH	.272	8.75	3.2×10^4	17.4
NaOH	.445	12.66	2.8×10^4	15.2

Table 2: The per cent of various nuclei in catode for KOH and NaOH electrolysis.

KOH				
Element(Z, N)	Al(13, 27)	Si(14, 28)	Cl(17, 18)	K(19, 20)
		0.94		4.50
Element(Z, N)	Ca(20, 20)	Cr(24, 28))	Fe(26, 29)	Cu(29, 34)
		1.90	93.0	0.45
NaOH				
Element(Z, N)	Al(13, 27)	Si(14, 28)	Cl(17, 18)	K(19, 20)
	1.10	0.55	0.20	0.60
Element(Z, N)	Ca(20, 20)	Cr(24, 28))	Fe(26, 29)	Cu(29, 34)
	0.40	1.60	94.0	0.65

2. For Al, Si, and Ca the reaction occurring only for Na should involve Na ions absorbed by the catode and suffering cold fusion with some particles -call them just X - to be identified.

3. Cu is the only element heavier than Fe and is expected to be produced by fusion with X. Quite generally, the fractions are of order one per cent.

4. The authors suggests that the extra volume of H_2 and O_2 molecules is due to nuclear reactions in the catode. A test for this hypothesis would be the ratio of H_2 and O_2 volumes. Large deviation from value 2 would support the hypothesis. The value near 2 would in turn support the hypothesis that the water produced by electrolysis is considerably denser than ordinary water.

3.2 $H_{1.5}O$ Anomaly And Nuclear String Model

It would seem that some exotic nuclei, perhaps consisting of protons, should be involved with the cold fusion. Concerning the identification of these exotic particles there are several guidelines. $H_{1.5}O$ anomaly, anomalous production of e^+e^- pairs in heavy ion collisions, and nuclear string model.

3.2.1 $H_{1.5}O$ anomaly and anomalous production of electron-positron pairs in heavy ion collisions

There exists an anomaly which could be explained in terms of long open nuclear strings. The explanation of $H_{1,5}O$ anomaly [D13, D10, D15, D9] discussed in [K8] as a manifestation of dark protons was one of the first applications of TGD based ideas about dark matter. The proposed explanation is that the fraction of 1/4 of protons is in atto-second time scale dark and invisible in electron scattering and neutron diffraction. Note that atto-second time scale corresponds to the time during which light travels a length of order atomic size.

A natural identification of the dark protons would be in terms of protonic strings behaving like nuclei having anomalously large size, which would be due to the anomalously large value of Planck constant. A partial neutralization by negatively charge color bonds would make these states stable.

The TGD based explanation of anomalous production of electron-positron pairs in the collisions of heavy nuclei just above the Coulomb wall [K23] is in terms of lepto-pions consisting of pairs of color octet electron and positron allowed by TGD and having mass slightly below $2m_e \simeq 1$ MeV. The strong electromagnetic fields created in collision create coherent state of lepto-pions decaying into electron positron pairs.

3.2.2 Nuclear string model

The nuclear string model describes nuclei as string like structures with nucleons connected by color magnetic flux tubes whose length is of order electron Compton length about 10^{-12} meters and even longer and thus much longer than the size scale of nuclei themselves which is below 10^{-14} meters. Color magnetic flux tubes define the color magnetic body of nucleus and each flux tube has colored fermion and anti-fermion at its ends. The net color of pair is non-vanishing so that color confinement binds the nucleons to the nuclear string. Nuclei can be visualized as structures analogous to plants with nucleus taking the role of seed and color magnetic body of much larger size taking the role of plant with color flux tubes however returning back to another nucleon inside nucleus.

One can imagine two basic identifications of the fermions.

1. For the first option fermions are identified as quarks. The color flux tube can have three charge states $q = +1, 0, -1$ according to whether it corresponds to $u\overline{d}, u\overline{u} + d\overline{d}$, or $\overline{u}d$ type state for quarks. This predicts a rich spectrum of exotic nuclei in which neutrons consist actually of proton plus negatively charged flux tube. The small mass difference between neutron and proton and small mass of the quarks (of order MeV) could quite well mean that these exotic nuclei are identified as ordinary nuclei. The findings of [C9] [C9] support the identification as quarks.

2. Lepto-hadron hypothesis [K23] encourages to consider also the possibility that color bonds have color octet electrons at their ends. This would make it easier to understand why lepto-pions are produced in the collisions of heavy nuclei.

3. One can also consider the possibility that the color bonds are superpositions of quark-antiquark pairs and colored electron-positron pairs.

3.2.3 Two options

One can consider two options for protonic strings. Either their correspond to open strings connected by color magnetic flux tubes or protons are dark so that giant nuclei are in question.

1. Protonic strings as open strings?

Color flux tubes connecting nucleons are long and one can ask whether it might be possible also open nuclear strings with long color flux tubes connecting widely separate nucleons even at atomic distance. These kind of structures would be favored if the ends of nuclear string are charged.

Even without assumption of large values of Planck constant for the color magnetic body and quarks the net length of flux tubes could be of the order of atomic size. Large value $\hbar$ would imply an additional scaling.

The simplest giant nuclei constructible in this manner would consist of protons connected by color magnetic flux tubes to from an open string. Stability suggest that the charge per length is not too high so that some minimum fraction of the color bonds would be negatively charged. One could speak of exotic counterparts of ordinary nuclei differing from them only in the sense that size scale is much larger. A natural assumption is that the distance between charged protonic space-time sheets along string is constant.

In the sequel the notation $X(z, n)$ will be is used for the protonic string containing net charge z and n negatively charged bonds. $a = z + n$ will denote the number of protons. z, n and a are analogous to nuclear charge Z, neutron number N, and mass number A. For open strings the charge is $z \geq 1$ and for closed strings $z \geq 0$ holds true.

This option has however problem. It is difficult imagine how the nuclear reactions could take place. One can imagine ordinary stringy diagrams in which touching of strings means that proton

of protonic string and ordinary nucleus interact strongly in ordinary sense of the word. It is however difficult to imagine how entire protonic string could be absorbed into the ordinary nucleus.

2. Are protons of the protonic string dark?

Second option is that protonic strings consist of dark protons so that nuclear space-time-sheet has scale up size, perhaps of order atomic size. This means that fermionic charge is distributed in much larger volume and possibly also the fermions associated with color magnetic flux tubes have scaled up sized. The value $\hbar = 2^{11}\hbar_0$ would predict Compton length of order 10^{-12} m for nucleon and upper size of order 10^{-11} for nuclei.

Cold nuclear reactions require a transformation of dark protons to ordinary ones and this requires leakage to the sector of the imbedding space in which the ordinary nuclei reside (here the book metaphor for imbedding space is very useful). This process can take place for a neutral part of protonic string and involves a reduction of proton and fermion sizes to normal ones. The phase transition could occur first only for a neutral piece of the protonic string having charges at its ends and initiate the nuclear reaction. Part of protonic string could remain dark and remaining part could be "eaten" by the ordinary nucleus or dark protonic string could "eat" part of the ordinary nuclear string. If the leakage occurs for the entire dark proton string, the nuclear reaction itself is just ordinary nuclear reaction and is expected to give out ordinary nuclei. What is important that apart from the crucial phase transition steps in the beginning and perhaps also in the end of the reaction, the model reduces to ordinary nuclear physics and is in principle testable.

The basic question is how plasma phase resulting in electrolysis leads to the formation of dark protons. The proposal [K10] that the transition takes place with perturbative description of the plasma phase fails, might be more or less correct. Later a more detailed nuclear physics picture about the situation emerges.

3. What happens to electrons in the formation of protonic strings?

One should answer two questions.

1. What happens to the electrons of hydrogen atoms in the formation of dark protonic strings?

2. In plasma electrolysis the increase of the input voltage implies a mysterious reduction of the electron current with the simultaneous increase of the size of the plasma region near the catode [C17]. This means reduction of conductance with voltage and thus non-linear behavior. Where does electronic charge go?

Obviously the negatively charged color bond created by adding one proton to a protonic string could take the charge of electron and transform electrons as charge carriers to color bonds of dark Li isotopes which charge $Z = 3$ by gluing to existing protons sequence proton and negatively charged color bond. If the proton comes from H_2O OH^- replaces electron as a charge carrier. This would reduced the conductivity since OH^- is much heavier than electron. This kind of process and its reversal would take place in the transformation of hydrogen atoms to dark proton strings and back in atto-second time scale.

The color bond could be either $\overline{u}d$ pair or $e_8\overline{\nu}_8$ pair or quantum superposition of these. The basic vertex would involve the exchange of color octet super-symplectic bosons and their neutrino counterparts. Lepton number conservation requires creation of color singlet states formed of color octet neutrinos which ar bosons and carrying lepton number -2. One color confined neutrino pair would be created for each electron pair consumed in the process and might escape the system: if this happens, the process is not reversible above the time scale defined by colored neutrino mass scale of order.1 eV which happens to be of order.1 atto-seconds for ordinary neutrinos. Also ordinary nuclei could consist of nucleons connected by identical neutral color bonds (mostly).

The exchange of light counterparts of charged ρ mesons having mass of order MeV could lead to the transformation of neutral color bonds to charged ones. In deuterium cold fusion the exchange of charged ρ mesons between D and Pd nuclei could transform D nuclei to states behaving like di-neutrons so that cold fusion for D could take place. In the earlier proposal exchange of W^+ boson of scaled variant of weak interactions was proposed as a mechanism.

The formation of charged color bonds binding new dark protons to existing protonic nuclear strings or giving rise to the formation of completely new protonic strings would also increase of the rates of cold nuclear reactions.

Note that this picture leaves open the question whether the fermions associated with color bonds are quarks or electrons.

3.2.4 Nuclei and their dark variants must have same binding energy scale at nuclear quantum criticality

The basic question is what happens to the scale of binding energy of nuclei in the zooming up of nuclear space-time sheet. Quantum criticality requires that the binding energies scales must be same.

1. Consider first the binding energy of the nuclear strings. The highly non-trivial prediction of the nuclear string model is that the contributions of strong contact interactions at nuclear space-time sheet (having size $L < 10^{-14}$ m) to the binding energy vanish in good approximation for ground states with vanishing strong isospin. This means that the binding energy comes from the binding energy assignable to color bonds connecting nucleons together.

2. Suppose that this holds true in a good approximation also for dark nuclei for which the distances of nucleons at zoomed up nuclear space-time sheet (having originally size below 10^{-14} meters) are scaled up. As a matter fact, since the scale of binding energy for contact interactions is expected to reduce, the situation is expected to improve. Suppose that color bonds with length of order 10^{-12} m preserve their lengths. Under these assumptions the nuclear binding energy scale is not affected appreciably and one can have nuclear quantum criticality. Note that the length for the color bonds poses upper limit of order 100 for the scaling of Planck constant.

It is essential that the length of color bonds is not changed and only the size of the nuclear space-time sheet changes. If also the length and thickness of color bonds is scaled up then a naive scaling argument assuming that color binding energy related to the interaction of transforms as color Coulombic binding energy would predict that the energy scales like $1/\hbar$. The binding energies of dark nuclei would be much smaller and transformation of ordinary nuclei to dark nuclei would not take place spontaneously. Quantum criticality would not hold true and the argument explaining the transformation of ordinary Li to its dark counterpart and the model for the deuterium cold fusion would be lost.

3.3 A Model For The Observations Of Mizuno

The basic objection against cold nuclear reactions is that Coulomb wall makes it impossible for the incoming nuclei to reach the range of strong interactions. In order that the particle gets to the catode from electrolyte it should be positively charged. Positive charge however implies Coulomb wall which cannot be overcome with the low energies involved.

These two contradictory conditions can be satisfied if the electrolysis produces exotic phase of water satisfying the chemical formula $H_{1.5}O$ with 1/4 of protons in the form of almost neutral protonic strings can possess only few neutral color bonds. The neutral portions of the protonic string, which have suffered phase transition to a phase with ordinary Planck constant could get very near to the target nucleus since the charges of proton can be neutralized in the size scale of proton by the charges $\overline{u}$ and d quarks or e and $\overline{\nu}$ associated with the two bonds connecting proton to the two neighboring protons. This could make possible cold nuclear reactions.

It turns out that the model fixes protonic strings to isotopes of dark Lithium (with neutrons replaced with proton plus negatively charged color bond). What is intriguing is that the biologically most important ions (besides Na^+) Cl^-, K^+, and Ca^{++} appear at the catode in Kanarev's plasma electrolysis actually result as outcomes of cold nuclear reactions between dark Li and Na^+.

3.3.1 General assumptions of the model

The general assumptions of the model are following.

1. Ordinary nuclei are nuclear strings, which can contain besides neutrons also "pseudo-neutrons" consisting of pairs of protons and negatively charged color bonds. The model for D cold fusion requires that the Pd nuclei contain also "pseudo-neutrons".

2. Reaction products resulting in the fusion of exotic protonic string transforming partially to ordinary nuclear matter (if originally in dark phase) consist of the nuclei detected in the catode plus possibly also nuclei which form gases or noble gases and leak out from the catode.

3. Si, K, Cr, and Cu are produced by the same mechanism in both KOH and NaOH electrolysis.

4. Al, Cl, and Ca is produced by a mechanism which must involve cold nuclear reaction between protonic string and Na ions condensed on the catode.

5. $Cu(Z, N) = Cu(29, 34)$ is the only product nucleus heavier than $Fe(26, 29)$. If no other nuclei are involved and Cu is produced by cold fusion

$$X(z, n) + Fe(26, 29) \to Cu(29, 34) \ ,$$

the anatomy of protonic string must be

$$X(z, n) = X(3, 5)$$

so that dark variant $Li(3, 5)$ having charge 3 and mass number 8 would be in question. $X(3, 5)$ would have 2 neutral color bonds and 5 negatively charged color bonds. To minimize Coulomb interaction the neutral color bonds must reside at the ends of the string. For quark option one would have charge $1 + 2/3$ at the first end and $1 + 1/3$ at the second end and charges of all protons between them would be neutralized. For color octet lepton color bond one would have charge 2 at the other end and zero at the other end.

For quark option the net protonic charge at the ends of the string causing repulsive interaction between the ends could make protonic string unstable against transition to dark phase in which the distance between ends is much longer even if the ends are closed within scaled up variant of the nuclear volume.

Arbitrarily long strings $X(3, n)$ having neutral bonds only at their ends are possible and their fusions lead to neutron rich isotopes of Cu nucleus decaying to the stable isotope. Hence the prediction that only Cu is produced is very general.

The simplest dark protonic strings $X(3, n)$ have quantum numbers of $Li(3, n)$. One of the hard problems of Big Bang cosmology is that the measured abundance of lithium is by a factor of about 2.5 lower than the predicted abundance [E3]. The spontaneous transformation of $Li(3, n)$ isotopes to their dark variants could explain the discrepancy. Just by passign notice that Li has mood stabilizing effect [C2]: the spontaneous transformation of Li^+ to its dark variant might relate to this effect.

3.3.2 Production mechanisms for the light nuclei common to Na and K

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These nuclei must be produced by a fission of Fe nuclei.

1. For $Si(14, 14)$ production the mechanism would be cold fission of Fe nucleus to two parts in the collision with the protonic string:

$$X(3, 5) + Fe(26, 29) \to Si(14, 14) + Al(13, 14) + X(2, 6) \ .$$

$X(2, 6)$ represent dark or ordinary $He(2, 6)$. As a noble gas He isotope would leave the catode.

Note that arbitrarily long proton strings with two neutral bonds at their ends give neutron rich isotope of Si and exotic or ordinary isotope of He so that again the prediction is very general.

2. $K(19,20)$ is produced much more in KOH which most probably means that part of K^+ is absorbed from the electrolyte. In this case the reaction could proceed as follows:

$$X(3,5) + Fe(26,29) \to K(19,20) + Ne(7,7) + X(3,7) \ .$$

Note that the neutron number could be distributed in many manners between final states. For arbitrarily long proton string with two neutral bonds at ends higher neutron rich isotopes of K and Ne are produced. As noble gas Ne would leak out from the catode.

Ordinary $Li(3,7)$ would decay by neutron emission to stable isotopes of Li. The temperature of the system determines whether Li boils out (1615 K under normal pressure). Li is not reported to appear in the catode. In plasma electrolysis the temperature is in the interval $.5 \times 10^4$- 10^4 C and around 10^3 C in the ordinary electrolysis so that the high temperature might explain the absence of Li. Also the in-stability of Li isotopes against transition to dark Li in electrolyte would imply the absence of Li.

3. For $Cr(24,28)$ production the simplest reaction would be

$$X(3,5) + Fe(26,29) \to Cr(24,28) + He(2,2) + X(3,4) \ .$$

Helium would leak out as noble gas. Proton string would shorten by one unit and keep its charge. $X(3,4)$ would represent the stable isotope $Li(3,4)$ or its dark counterpart and what has been said in 2) applies also now.

3.3.3 How to understand the difference between KOH and NOH?

One should understand why Al, Cl, and Ca are not detected in the case of KOH electrolysis.

Al, Cl, and Ca would be created in the fusion of protonic strings with $Na(11,12)$ nuclei absorbed by the catode. With this assumption the rates are expected to be of same order of magnitude for all these processes as suggested by the one per cent order of magnitude for all fractions.

One can imagine two reaction mechanisms.

I: One could understand the production assuming only $X(3,5)$ protonic strings if the number of $X(3,5)$ strings absorbed by single Na nucleus can be $k = 1,2,3$ and that nuclear fission can take place after each step with a rate which is slow as compared to the rate of absorptions involving also the phase transition to dark matter. This is however highly implausible since ordinary nuclear interactions are in question.

II: Second possibility is that the protonic strings appearing with the highest probability are obtained by fusing copies of the basic string $X(3,5)$ by using neutral color bond between the strings. The minimization of electrostatic energy requires that that neutral color bonds are equally spaced so that there are three completely neutralized protons between non-neutralized protons.

One would have thus at least the strings $X(3,5)$, $X(6,10)$, and $X(9,15)$, which correspond to dark $Li(3,5)$ and dark variants of the unstable isotopes $C(6,10)$ and $F(9,15)$. In nuclear string model also ordinary nuclei are constructed from $He(2,2)$ strings and lighter strings in completely analogous manner, and one could perhaps see the dark nuclei constructed from $Li(3,5)$ as the next level of hierarchy realized only at the level of dark matter.

The charge per nucleon would be 3/8 and the length of the string would be a multiple of 8. Interestingly, the numbers 3, 5, and 8 are subsequent Fibonacci numbers appearing very frequently also in biology (micro-tubules, sunflower patterns). The model predicts also the occurrence of cold fusions $X(z = 3k, n = 5k) + Fe(26,29) \to (Z,N) = (26 + 3k, 29 + 5k)$. For $k = 2$ this would give $Ge(32,39)$ which is stable isotope of Ge. For $k = 3$ one would have $(Z,N) = (35,44)$ which is stable isotope of Br [C24, C4].

Consider now detailed description of the reactions explaining the nuclei detected in the catode.

1. $Al(13,14)$ would be produced in the reaction

$$X(3,5) + Na(11,12) \to Al(13,14) + X(1,3) \ .$$

$H(1,3)$ or its dark variant could be in question. Also the reaction $X(3,5) + Na(11,12) \to Al(13,17) + p$, where $Al(12,17)$ is an unstable isotope of Al is possible.

The full absorption of protonic string would yield $Si(14,17)$ beta-decaying to $P(15,16)$, which is stable. Either P leaks out from the catode or full absorption does not take place appreciably.

2. $Cl(17,18)$ would be produced by the sequence

$$\begin{aligned} \mathbf{I1}: \quad & 2X(3,5) + Na(11,12) \quad \to \quad Cl(17,18) + X(0,4) \ , \\ \mathbf{I2}: \quad & X(6,10) + Na(11,12) \quad \to \quad Cl(17,18) + X(0,4) \ . \end{aligned}$$

$X(0,4)$ represents ordinary or dark tetra-neutron [C22, C16, C8]. The instability of the transformation of tetra-neutron to dark matter could explain why its existence has remained controversial.

If the protonic string were absorbed completely, the resulting $Cl(17,22)$ - if equivalent to ordinary nucleus - would transform via beta-decays to $A(18,23)$ and then to $K(19,22)$, which is stable and detected in the target.

3. $Ca(20,20)$ would be produced in the reaction

$$\begin{aligned} \mathbf{I1}: \quad & 3X(3,5) + Na(11,12) \quad \to \quad Ca(20,20) + X(0,7) \ , \\ \mathbf{I2}: \quad & X(9,15) + Na(11,12) \quad \to \quad Ca(20,20) + X(0,7) \ . \end{aligned}$$

$X(0,7)$ would be dark counterpart of "septa-neutron". The complete absorption of nuclear string would produce $Ca(20,27)$, which (if ordinary nucleus) transforms via beta decays to $Sc(21,26)$ and then to $Ti(22,25)$, which is stable.

3.4 Comparison With The Model Of Deuterium Cold Fusion

It is interesting to compare the model with the model for cold fusion [C21, C1] reported using deuterium target and D_2O instead of water.

3.4.1 Earlier model

1. The model is based on the assumption that D nuclei in the target suffer a phase transition to a state in which D nuclei become neutral so that the color bond between neutron and proton becomes negatively charged: one has effectively di-neutrons.

2. The mechanism of charging of color bond must either involve weak interactions or exchange of lepto-ρ mesons already discussed briefly. The proposal is that the exchange of W bosons of scaled up version of weak physics is involved with the range of interactions given by atomic length scale. The exchange of W^+ bosons was assumed to take place between Pd and D nuclei. This mechanism could lead to the formation of negatively charged color bonds in also ordinary nuclei.

3. The neutrality of exotic D nuclei allows to overcome Coulomb wall. One can understand the reported selection rules: in particular the absence of Helium isotopes (only isotopes of H are detected). The absence of gamma rays can be understood if the resulting gamma rays are dark and leak out before a transformation to ordinary gamma rays.

3.4.2 Are D nuclei in Pd target dark or not?

The question whether the exotic D nuclei are dark was left pending. The recent model suggests that the answer is affirmative.

1. The basic difference between the two experiments would be that in Kanarev's experiments incoming nuclei are dark whereas in D fusion catode contains the dark nuclei and cold nuclear reactions occur at the "dark side" and is preceded by ordinary-to-dark phase transition for incoming D.

2. D cold fusion occurs for a very restricted range of parameters characterizing target: the first parameter is doping ratio: essentially one D nucleus per one Pd nucleus is needed which would fit with the assumption that scaled up size is of the order of atom size. Temperature is second parameter. This and the fact that the situation is highly sensitive to perturbations conforms with the interpretation as a phase transition to dark matter occurring at quantum criticality.

3. The model for Kanarev's findings forces to consider the possibility that dark D nuclei combine to form longer strings and can also give rise to dark $Li(3,5)$ explaining the observed nuclear transmutations in the target.

4. In cold nuclear reactions incoming nuclei would transform to dark nuclei (the picture as a leakage between different pages of a book like structure defined by the generalized imbedding space is helpful). The reaction would take place for dark nuclei in zoomed up nuclear physics and the reaction products would be unstable against phase transition to ordinary nuclei.

5. Is it then necessary to assume that target D nuclei are transformed to neutral ones (di-neutrons effectively) in order to have cold nuclear reactions? Nuclear space-time sheets are scaled up. If nucleon space-time sheets are not scaled up, p and n are connected by color magnetic flux tubes of same length as in the case of ordinary nuclei but located at much larger nuclear space-time sheet. The classical analog for the quantal distribution of nucleon charges is even charge distribution in a sphere or radius R defined by the charge of the scaled up nucleus. The height of the Coulomb wall is $E_c = e^2/R$. If $R = a$, a the atomic radius, one has $E_c \sim .1$ keV. The wall is by a factor 10^{-4} lower than in ordinary nuclear collision so that the incoming D nucleus might overcome the Coulomb wall.

   If Coulomb wall can be overcome, all dark variants of $D + D$ reaction are possible. Helium nuclei have not been however detected, which supports the view that D in target is transformed to its neutral variant. Gamma rays would be dark and could leak out without detection which would explain the absence of gamma rays.

3.4.3 Nuclear quantum criticality is essential

A note about the energetics of cold nuclear reactions is in order. The nuclear quantum criticality deriving from the cancelation of the contact interaction energies between nucleons for isospin singlets and scaling up of *only* nuclear space-time sheet is an absolutely essential assumption. Otherwise dark D would have much smaller binding energy scale than the visible one, and ordinary D in the Pd target could not transform to dark "di-neutron" state. Also the transformation of incoming D to its dark variant D at catode could not take place.

3.5 What Happens To Oh Bonds In Plasma Electrolysis?

For an innocent novice one strange aspect of hydrolysis is how the OH bonds having energies of order 8 eV can be split in temperatures corresponding to photon energies of order.5 eV. Kanarev has suggested his own theory for how this could happen [D14]. TGD suggests that OH bonds are transformed to their dark variants with scaled down bond energy and that there might be no essential difference between OH bond and hydrogen bond.

3.5.1 The reduction of energy of OH bonds in plasma electrolysis

Kanarev has found that in plasma electrolysis the energy of OH bonds is reduced from roughly 8 eV to about.5 eV, which corresponds to the fundamental metabolic energy quantum identifiable as the zero point kinetic energy liberate as proton drops from $k = 137$ space-time sheet to much larger space-time sheet. In pyrolysis [D4] similar reduction could occur since the pyrolysis occurs above temperature about 4000 C conforming with the energy scale of hydrogen bond.

The explanation discussed in [K22] is that there is some mechanism exciting the bonds to a state with much lower bond energy. Dark matter hierarchy [K10] suggests that the excitation corresponds to the transformation of OH bond to dark bond so that the energy scale of the state is reduced.

Also in the ordinary electrolysis of water [D2] the energy of OH bonds is reduced to about 3.3 eV meaning a reduction factor of order 2. The simplest interpretation would be as a transformation of OH bonds to dark OH bond with $\hbar \to 2\hbar$ (the scaling could be also by some other integer or even rational). The energy needed to transform the bond to dark bond could come from remote metabolism via the dropping of dark protons from a dark variant of some sub-atomic space-time sheet with size not smaller than the size of the atomic space-time sheet to a larger space-time sheet.

In many-sheeted space-time (see **Fig.** `http://tgdtheory.fi/appfigures/manysheeted.jpg` or **Fig.** 9 in the appendix of this book) particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated.

$H_{1.5}O$ anomaly suggests that 1/4 of protons of water are dark in atto-second time scale [K8] and one can imagine that both protons of water molecule can become dark under conditions defined by plasma electrolysis. Also the atomic space-time sheets and electron associated with OH bonds could become dark.

Atomic binding energies transform as $1/\hbar^2$. If the energy of hydrogen bond transforms like Coulombic interaction energy as given by the perturbative calculation, it is scaled down as $1/\hbar$ since the length of the bond scales up like $\hbar$. Effectively $\alpha_{em} \propto 1/\hbar$ is replaced by its scaled down value. For $\hbar \to 2^4\hbar_0$ the energy would scale from 8 eV to.5 eV and the standard metabolic energy quantum could induce the splitting of the dark OH bond. If 2^4 is the scale factor of $\hbar$ for dark nuclear space-time sheets, their size would be of order 10^{-3} meters. The model for cold fusion is consistent with this since what matters is different value of Planck constant for the dark nuclear space-time sheets.

There is an objection against the reduction of OH bond energy. The bonds could be split by a process in which dark nuclear reactions kick protons to $k = 133$ dark space-time sheet. In this case the maximal zero point kinetic energy liberated in the dropping back would be 8 eV and could induce breaking of OH bond. For $\hbar/\hbar_0 \geq 4$ the size of $k = 133$ dark space-time sheet would be larger than the size of $k = 137$ atomic space-time sheet.

3.5.2 Are hydrogen bonds dark OH bonds?

The fact that the energy of hydrogen bonds [D3] is typically around.5 eV forces to ask what distinguishes hydrogen bond from dark OH bond. Could it be that the two bonds are one and the same thing so that dark OH bonds would form standard part of the standard chemistry and molecular biology? In hydrogen bond same hydrogen would be shared by the oxygen atoms of the neighboring atoms. For the first O the bond would be ordinary OH bond and for the second O its dark variant with scaled down Coulomb energy. Under conditions making possible pyrolysis and plasma electrolysis both bonds would become dark. The variation of the hydrogen bond energy could reflect the variation of the scaling factor of $\hbar$.

The concentration of the spectrum of bond energies on integer multiples of fundamental energy scale - or even better, on powers of 2 - would provide support for the identification. There is evidence for two kinds of hydrogen bonds with bond energies in ratio 1: 2 [D12] : the TGD based model is discussed in [K8].

3.5.3 Mechanism transforming OH bonds to their dark counterparts

The transformation of OH bonds to dark bonds would occur both in ordinary and plasma electrolysis and only the change of Planck constant would distinguish between the two situations.

1. Whatever the mechanism transforming OH bonds to their dark counterparts is, metabolic energy is needed to achieve this. Kanarev also claims over-unity energy production [D14]. Cold fusion researchers make the same claim about ordinary electrolysis. Cold nuclear reactions between Na^+ (K^+) and dark protons and dark Li could obviously serve as the primary energy source. This would provide the fundamental reason for why $NaOH$ or KOH must

be present. Cold nuclear reactions would thus occur also in the ordinary electrolysis of water and provide the energy inducing the transition of OH bonds to dark ones by (say) $\hbar \to 2\hbar$ transition.

2. One can imagine several metabolic mechanisms for the visible-to-dark transformation of HO bonds. The energy spectrum of cold nuclear reactions forms a continuum whereas the energies needed to transform OH bonds to their dark variants presumably are in narrow bands. Therefore the energy liberated in cold nuclear reactions is not probably used as such. It is more plausible that standard metabolic energy quanta liberated in the dropping of protons (most naturally) to larger space-time sheets are utilized. The most important metabolic energy quanta for the dropping of proton come as $E_k = 2^{k-137}kE_0$: $E_0 = .5$ eV is liberated in the dropping of proton from atomic space-time sheet ($k = 137$) to much larger space-time sheet (the discrete spectrum of increments of the vacuum energy in the dropping approaches this energy [K17]). The energy liberated in the dark nuclear reactions would "load metabolic batteries" by kicking the dark protons to the dark variants of $k < 137$ space-time sheet (the size of dark atomic space-time sheet scales like $\hbar$). Their dropping to larger space-time sheets would liberate photons with energies near to those transforming OH bonds to hydrogen bonds.

3. A signature for the standard metabolic energy quanta would be visible light at $2eV$ and also discrete lines below it accumulating to $2eV$. Kanarev's indeed reports the presence of red light [D14] as a signature for the occurrence of process.

3.6 A Model For Plasma Electrolysis

Kanarev's experiments involve also other strange aspects which lead to the view that cold nuclear reactions and dark matter physics are essential aspects of not only plasma electrolysis of Kanarev but also of ordinary electrolysis and responsible for the claimed over unity energy production. Biologically important ions are produced in reactions of dark Li and Na^+ and there is very strong electric voltage over the cell membrane. This inspires the question whether cold nuclear reactions serve as a metabolic energy source in living cell and are also responsible for production of ions heavier than Na^+.

3.6.1 Brief description of plasma electrolysis

Electrolysis [D2], pyrolysis [D4] , and plasma electrolysis [C17], [D14] of water are methods of producing free hydrogen. In pyrolysis the temperature above 4000 C leads to hydrogen and oxygen production. Oxygen production occurs also at catode and hydrogen yield is higher than given by Faraday law for ordinary electrolysis [D2].

The article of Mizuno and collaborators [C17] about hydrogen production by plasma electrolysis contains a brief description of plasma electrolysis. A glow discharge occurs as the input voltage used in electrolysis is above a critical value and plasma is formed near catode. In the arrangement of [C17] plasma state is easily achieved above 140 V. If the values of temperature and current density are right, hydrogen generation in excess of Faraday's law as well as a production of oxygen at catode (not possible in ideal electrolysis) are observed. Above 350 V the control of the process becomes difficult.

3.6.2 What really happens in electrolysis and plasma electrolysis?

1. Ordinary electrolysis

To understand what might happen in the plasma electrolysis consider first the ordinary electrolysis of water.

1. The arrangement involves typically the electrolyte consisting of water plus $NaOH$ or KOH without which hydrolysis is impossible for thermodynamical reasons.

2. Electronic current flows from the anode to catode along a wire. In electrolyte there is a current of positively charged ions form anode to catode. At the catode the reaction $2H_2O + 2e^- \to$

$2H_2 + 2OH^-$ yields hydrogen molecules seen as bubbles in water. At the anode the reaction $2H_2O \to O_2 + 4H^+ + 4e^-$ is followed by the reaction $2H^+ + 2e^- \to H_2$ and the flow of $2e^-$ to the catode along wire. The net outcome is hydrolysis: $H_2O \to 2H_2 + 2O_2$. Note that O_2 is produced only at anode and H_2 at both anode and catode.

2. What happens in plasma electrolysis?

In plasma electrolysis something different might happen.

1. Cold nuclear reactions should take place at catode in presence of Na^+ ions plus dark Li and should be in equilibrium under ordinary conditions and contribute mainly to the formation of dark OH bonds. The rate of cold nuclear reactions increases with input voltage V since the currents of Na^+ and dark Li to the catode increase. Obviously the increased rate of energy yield from dark nuclear reactions could be the real reason for the formation of plasma phase above critical voltage.

2. By previous considerations the reduction of electron current above critical voltage has interpretation as a transition in which electronic charge is transferred to negative charge of color bonds of dark proton strings. Existing protonic strings could grow longer and also new strings could be created from the ionized hydrogen resulting in the electrolysis of water. The increase of the size of the dark nuclei would mean increase of the cross sections for cold nuclear reactions. The liberated energy would ionized hydrogen atoms and give rise to a positive feedback loop somewhat like in ordinary nuclear reactions.

3. The increased energy yield in cold nuclear reactions suggests that OH bonds are transformed very effectively to dark OH bonds in the plasma region. This means that the thermal radiation can split the hydrogen bonds and induce the splitting of two water molecules to $4H$ and $2O$ and therefore production of $2H_2 + O_2$ everywhere in this kind of region. The temperature used by Kanarev corresponds to energy between .5-1 eV [D14] which conforms with the fact that OH bond energy is reduced to about.5 eV. Note that the presence of anode and catode is not absolutely necessary if cold nuclear reactions can take place in the entire electrolyte volume and generate plasma phase by positive feedback loop.

4. The prediction is that Faraday's law for hydrogen production does not hold true. O/H ratio has the value $r = O/H = 0$ for the ordinary electrolysis at catode. $r = 1/2$ holds true if local dissociation of water molecules dominates. According to [C17] r increases from electrolysis value $r = .066$ above $V = 140$ V achieving the value $r = .45$ for $V = 350$ V where the system becomes unstable. Also cold nuclear reactions could contribute to hydrogen and oxygen production and affect the value of r as suggested by the large volume of gas produced in Kanarev's experiments [D11].

3.6.3 Over-unity energy production?

Over-unity energy production with output power 2- or even 3-fold as compared with input power has been reported from plasma electrolysis. The effectiveness is deduced from the heating of of the system. Note that Mizuno reports in [C17] that 10 per cent effectiveness but this is for the storage of energy to hydrogen and does not take into account the energy going to the heating of water.

The formation of higher isotopes of Li by fusing dark protons to existing dark proton strings is a good candidate for the dominant energy production mechanism. An estimate for the energy liberate in single process $Li(3,n) + m_p + e \to Li(3,n+1) + 2\nu_8$ is obtained by using energy conservation. Here $2\nu_8$ denotes color singlet bound state of two color octet excitations of neutrino.

Since e_8 and ν_8 are analogous to u and d quarks one expects that their masses are very nearly the same. This gives as the first guess $m_{\nu_8} = m_e$ and since lepto-pion (color bound state of color octet electrons, [K23]) has mass $m = 2m_e$ a good guess is $m(2\nu_8) = 2m_{\nu_8} = 2m_e$. The energy conservation would give

$$m(Li(3,n)) + m_p \quad = \quad m(Li(3,n+1)) + m_e + T(2\nu_8) + E(\gamma) \ . \tag{3.1}$$

Here $T(2\nu_8)$ is the kinetic energy of $2\nu_8$ state and E_γ is the energy of photon possibly also emitted in the process.

The process is kinematically possible if the condition

$$\Delta m \quad = \quad m(Li(3,n)) + m_p - m(Li(3,n+1) \geq m_e \quad . \tag{3.2}$$

is satisfied. All incoming particles are approximated to be at rest, which is a good approximation taking into account that chemical energy scales are much lower than nuclear ones. For the left hand side one obtains from the mass difference of $Li(3,n=4)$ and $Li(3,5)$ isotopes the estimate $\Delta m = 1.2312$ MeV for the liberated binding energy which is considerably larger than $m_e = .51$ MeV. Hence the process is kinematically possible and $2\nu_8$ would move with a relativistic velocity $v = .81c$ and presumably leave the system without interacting with it.

The process can involve also the emission of photons and the maximal amount of energy that photon can carry out corresponds to $E = \Delta m = 1.2312$ MeV. Let us denote by $\langle E \rangle < \Delta m$ the average photonic energy emitted in the process and express it as

$$\langle E \rangle = z\Delta m \quad , \quad z < 1. \tag{3.3}$$

One obtains an estimate for the production rate of photon energy (only this heats the system) from the incoming electron current I. If a fraction $x(V)$ of the current is transformed to negatively charged color bonds the rate for energy production becomes by a little manipulation

$$\frac{P/kW}{I/A} \quad = \quad x(V)z \times 3.5945 \quad . \tag{3.4}$$

This formula allows to estimate the value of the parameter $x(V)z$ from experimental data. Since simplest Feynman graph producing also photons is obtained by adding photon line to the basic graph, one expects that z is of order fine structure constant:

$$z \quad \sim \quad \alpha_{em} = 1/137 \quad . \tag{3.5}$$

The ratios of the excess power for a pair of (V, I) values should satisfy the condition

$$\frac{P(V_1)I(V_2)}{P(V_2)I(V_1)} \quad = \quad \frac{x(V_1)}{x(V_2)} \quad . \tag{3.6}$$

$x(V)$ should be deducible as a function of voltage using these formulas if the model is correct.

These formulae allow to compare the predictions of the model with the experimental results of Naudin for Mizuno-Omori Cold Fusion reactor [C6]. **Table 3** gives the values of $\epsilon = x(V)z$ and ratios $x(V(n))/x(V(n_1)$ deduced from the data tabulated by Naudin [C20] for the various series of experiments using the formulae above.

1. Most values of $x(V)z$ are in the range $.03 - .12$. $z = 1/137$ would give $x(V)z \leq 1/137$ so that order of magnitude is predicted correctly. One cannot over-emphasize this result.

2. Apart from some exceptions the values look rather reasonable and do not vary too much. If one neglects the exceptional values, ones has $x_{max}(V)/x_{min}(V) < 4$. $n = 1, 5, 8, 9, 29$ correspond to exceptionally small values of $x(V)$. Perhaps cold fusion is not present for some reason. The output power is smaller than input power for $n = 9$ and $n = 29$.

Table 3: The values of $x(V)z$ and $x(V(n))/x(V(1))$ deduced from the data of *Cold Fusion reaction-Experimental test results on June 25, 2003 by JL Naudin* at `http://jlnlabs.online.fr/cfr/html/cfrdatas.htm`.

n	$Voltage/V$	$Current/A$	$x(V)z$	$x(V(n))/x(V(2))$
1	185	8.56	0.005	.145
2	147	2.45	0.036	1.00
3	215	2.10	0.046	1.30
4	220	9.32	0.044	1.22
5	145	1.06	0.001	.03
6	213	1.40	0.05	1.34
7	236	1.73	0.08	2.18
8	148	.83	0.01	.21
9	148	1.01	-0.00	-0.008
10	221	1.31	0.03	.87
11	279	3.03	0.05	1.46
12	200	8.58	0.03	0.89
13	199	7.03	0.07	1.91
14	215	9.78	0.04	1.07
15	207	8.34	0.03	0.74
16	247	2.19	0.06	1.69
17	260	2.20	0.02	0.55
18	257	2.08	0.03	0.71
19	195	2.95	0.06	1.59
20	198	2.62	0.07	1.98
21	182	2.40	0.05	1.26
22	212	2.27	0.06	1.74
23	259	2.13	0.12	3.22
24	260	4.83	0.04	1.05
25	209	3.53	0.04	1.16
26	230	4.99	0.10	2.79
27	231	5.46	0.09	2.53
28	233	5.16	0.10	2.85
29	155	4.60	-0.00	-0.04
30	220	4.44	0.11	2.95
31	256	5.25	0.05	1.36
32	211	3.68	0.03	.97
33	201	3.82	0.04	1.06

3.6.4 Has living matter invented cold nuclear physics?

Intriguingly, the ions Na^+, Cl^-, K^+, Ca^{++} detected by Mizuno in the catode in Kanarev's experiments [D11] correspond to the most important biological ions. There is also a considerable evidence for the occurrence of nuclear transmutations in living matter [C11, C25]. For instance, Kervran claims that it is not possible to understand where the Ca needed to form the shells of eggs comes from. A possible explanation is that dark nuclear reactions between Na^+ and dark Litium produced the needed Ca.

There is extremely strong electric field through cell membrane (resting voltage is about.06 V). The acceleration of electrons in this field could generate plasma phase and creation of dark Li nuclei via a positive feedback loop. This could mean that cold nuclear reactions serve also in living cell as a basic metabolic energy source (possibly in the dark sector) and that also biologically important ions result as products of cold nuclear reactions.

3.7 Tests And Improvements

3.7.1 Test for the hypothesis about new physics of water

The model involves hypothesis about new physics and chemistry related to water.

1. The identification of hydrogen bond as dark OH bond could be tested. One could check whether the qualitative properties of bonds are consistent with each. One could try to find evidence for quantization of bond energies as integer multiples of same energy (possible power of two multiples).

2. $H_{1.5}O$ formula in atto-second scale should be tested further and one could look whether similar formula holds true for heavy water so that sequences of dark protons might be replaced with sequences of dark deuterons.

3. One could find whether plasma electrolysis takes place in heavy water.

3.7.2 Testing of the nuclear physics predictions

The model in its simplest form assumes that only dark Li, C, F, etc. are present in water. This predicts quite specific nuclear reactions in electrolyte and target and reaction product. For both target and electrolyte isotopes of nuclei with atomic number $Z + k3$ are predicted to result in cold fusion reactions if energetically possible. For a target heavier than Fe also fission reactions might take place.

The estimates for the liberated energies are obtained assuming that dark nuclei have same binding energies as ordinary ones. In some cases the liberated energy is estimated using the binding energy per nucleon for a lighter isotope. Ordinary nuclei with maximal binding energy correspond to nuclear strings having ^4He or its variants containing negatively charged color bonds as a basic structural unit. One could argue that gluing $nLi(3,5)$ or its isotope does not give rise to a ground state so that the actual energy liberated in the process is reduced so that process might be even impossible energetically. This could explain the absence of Ge from Fe catode and the absence of Ti, Mn, and Ni in KOH plasma electrolysis [D11].

catode: For catode Fe and W have been used. For Fe the fusions $Fe+Li \to Cu+28.84\ MeV$ and $Fe + C \to Ge + 21.64\ MeV$ are possible energetically. Mizuno does not report the presence of Ge in Fe target. The reduction of the binding energy of dark $C(6,10)$ by 21.64 MeV (1.35 MeV per nucleon) would make second reaction impossible but would still allow $Li+C$ and $Na+C$ fusion. Second possibility is that Ge containing negatively charged color bonds has smaller binding energy per nucleon than ordinary Ge. $W + Li \to Ir$ would liberate 8.7 MeV if binding energy of dark Li is same as of ordinary Li.

Electrolyte: Consider electrolytes containing ions X^+ with atomic number Z. If X is lighter than Fe, the isotopes of nuclei with atomic number $Z + 3k$ might be produced in fusion reactions $nLi + X$. $X = Li, K, Na$ has one electron at s-shell whereas $B, Al, Cr, ...$ has one electron at p-shell.

Table 4: The estimates for the energies liberated in fusions of dark nuclei of water and the ion of electrolyte. Boldface refers to dark nuclei $Li(3,5), C(6,10)$, and $F(9,15)$.

Reaction	$\mathbf{Li} + Li \to C$	$\mathbf{C} + Li \to F$	$\mathbf{F} + Li \to Mg$
E/MeV	27.1	24.0	31.5
	$\mathbf{Li} + Na \to Si$	$\mathbf{C} + Na \to Cl$	$\mathbf{F} + Na \to Ca$
E/MeV	34.4	30.5	33.7
	$\mathbf{Li} + K \to Ti$	$\mathbf{C} + K \to Mn$	$\mathbf{F} + K \to Ni$
E/MeV	32.2	33.6	32.7

3.7.3 Relationship to the model of Widom and Larsen and further tests

W. Guglinski kindly informed me about the theory of cold fusion by Widom and Larsen [C28]. This theory relies on standard nuclear physics. The theory is reported to explain cold fusion reaction products nicely in terms of the transformation of electrons and protons to very low energy neutrons which can overcome the Coulomb barrier. The problem of the theory is that very high energy electrons are required since one has $Q = .78$ MeV for $e + p \to n$ and $Q = -3.0$ MeV for $e + D \to n + n$. It is difficult to understand how so energetic electrons could result in ordinary condensed matter.

Since proton plus color bond is from the point of view of nuclear physics neutron and the fusion reactions would obey ordinary nuclear physics rules, the predictions of TGD are not expected to deviate too much from those of the model of Widom and Larsen.

An important class of predictions relate to ordinary nuclear physics. Tetra-neutron could be alpha particle with two negatively charged color bonds and neutron halos could consist of protons connected to nucleus by negatively charged color bonds. This could reduce the binding energy considerably.

Cold nuclear fusion might also provide an in situ mechanism for the formation of ores. Nuclear ores in places where they should not exist but involving remnants of organic matter would be the prediction. Cold fusion has a potential for a technology allowing to generate some metals artificially.

3.7.4 How to optimize the energy production?

The proposed model for the plasma electrolysis suggests following improvements to the experimental arrangement.

The production of energy in process is due to three reactions: 1) Li+p in plasma. 2) Li+Fe/W... in target, and 3) $Li + Na/K$... in plasma. The model suggests that 1) dominates so that basic process would occur in plasma rather than catode.

1. Since W does not evaporate so easily, it is better material for catode if the production of dark Li dominates energy production.

2. catode could be replaced with a planar electrode with fractal peaky structure generating the required strong electric fields. This could increase the effectiveness of the energy production by increasing the effective area used.

3. Since $H_2O \to OH^- + p$ is required by the generation of dark Li sequences. The energy feed must be able to follow the rapidly growing energy needs of this reaction which seems to occur as bursts.

4. The prediction is that the output power is proportional to electron current rather than input power. This suggests minimization of input power by minimizing voltage. This requires maximization of electron conductivity. Unfortunately, the transformation of electrons to OH^- ions as charge carriers reduces conductivity.

4 Anomalies Possibly Related To Electrolysis Of Water And Cold Fusion

4.1 Burning Salt Water By Radio-Waves And Cold Fusion By Plasma Electrolysis

John Kanzius has made a strange discovery [D1]: salt water in the test tube radiated by radio waves at harmonics of a frequency f=13.56 MHz burns. Temperatures about 1500 C, which correspond to.17 eV energy have been reported. One can radiate also hand but nothing happens. The original discovery of Kanzius was the finding that radio waves could be used to cure cancer by destroying the cancer cells. The proposal is that this effect might provide new energy source by liberating chemical energy in an exceptionally effective manner. The power is about 200 W so that the power used could explain the effect if it is absorbed in resonance like manner by salt water. In the following it is proposed that the cold nuclear reactions are the source of the energy.

4.1.1 Do radio waves of large Planck constant transform to microwave photons or visible photons in the process?

The energies of photons involved are very small, multiples of 5.6×10^{-8} eV and their effect should be very small since it is difficult to imagine what resonant molecular transition could cause the effect. This leads to the question whether the radio wave beam could contain a considerable fraction of dark photons for which Planck constant is larger so that the energy of photons is much larger. The underlying mechanism would be phase transition of dark photons with large Planck constant to ordinary photons with shorter wavelength coupling resonantly to some molecular degrees of freedom and inducing the heating. Microwave oven of course comes in mind immediately. The fact that photosynthesis means burning of water and the fact that visible light is emitted in turn suggests that the radio wave photons are transformed to visible or nearly visible photons corresponding to the energy scale of photons involved with photosynthesis.

The original argument inspired by the analogy with microwave oven is discussed below. The generalization to the case of visible photons is rather straightforward and is discussed in [K8].

1. The fact that the effects occur at harmonics of the fundamental frequency suggests that rotational states of molecules are in question as in microwave heating. The formula for the rotational energies [D5] is

$$E(l) = E_0 \times (l(l+1)) \quad , \quad E_0 = \hbar_0^2/2\mu R^2 \quad , \quad \mu = m_1 m_2/(m_1+m_2) \quad .$$

   Here R is molecular radius which by definition is deduced from the rotational energy spectrum. The energy inducing the transition $l \to l+1$ is $\Delta E(l) = 2E_0 \times (l+1)$.

2. $NaCl$ molecules crystallize to solid so that the rotational heating of $NaCl$ molecules cannot be in question.

3. The microwave frequency used in microwave ovens is 2.45 GHz giving for the Planck constant the estimate 180.67 equal to 180 with error of.4 per cent. The values of Planck constants for $(\hat{M}^4/G_a)\times\hat{CP}_2\hat{\times}G_b$ option (factor space of M^4 and covering space of CP_2 maximizing Planck constant for given G_a and G_b) are given by $\hbar/\hbar_0 = n_a n_b$. $n_a n_b = 4\times 9\times 5 = 180$ can result from the number theoretically simple values of quantum phases $exp(i2\pi/n_i)$ corresponding to polygons constructible using only ruler and compass. For instance, one could have $n_a = 2\times 3$ and $n_b = 2\times 3\times 5$.

4.1.2 Connection with plasma electrolysis?

The burning of salt water involves also the production of O_2 and H_2 gases. Usually this happens in the electrolysis of water [D2]. The arrangement involves typically electrolyte consisting of water plus $NaOH$ or KOH present also now but anode, catode and electronic current absent. The proposed mechanism of electrolysis involving cold nuclear reactions however allows the splitting of water molecules to H_2 and O_2 even without these prerequisites.

The thermal radiation from the plasma created in the process has temperature about 1500 C which correspond to energy about.17 eV: this is not enough for splitting of bonds with energy.5 eV. The temperature in salt water could be however considerably higher.

The presence of visible light suggests that plasma phase is created as in plasma electrolysis. Dark nuclear reactions would provide the energy leading to ionization of hydrogen atoms and subsequent transformation of the electronic charge to that of charged color bonds in protonic strings. This in turn would increase the rate of cold nuclear reactions and the liberated energy would ionize more hydrogen atoms so that a positive feedback loop would result.

Cold nuclear reactions should provide the energy transforming hydrogen bonds to dark bonds with energy scaled down by a factor of about 2^{-6} from say 8 eV to.125 eV if $T = 1500C$ is accepted as temperature of water. If Planck constant is scaled up by the factor $r = 180$ suggested by the interpretation in terms of microwave heating, the scaling of the Planck constant would reduce the energy of OH bonds to about.04 eV, which happens to be slightly below the energy assignable to the cell membrane resting potential. The scaling of the size of nuclear space-time sheets of D by factor $r = 180$ is consistent with the length of color bonds of order 10^{-12} m. The role of microwave heating would be to preserve this temperature so that the electrolysis of water can continue. Note that the energy from cold nuclear reactions could partially escape as dark photons.

There are some questions to be answered.

1. Are the radio wave photons dark or does water - which is a very special kind of liquid - induce the transformation of ordinary radio wave photons to dark photons by fusing 180 radio wave massless extremals (MEs) to single ME. Does this transformation occur for all frequencies? This kind of transformation might play a key role in transforming ordinary EEG photons to dark photons and partially explain the special role of water in living systems.

2. Why the radiation does not induce a spontaneous combustion of living matter which also contains Na^+ and other ions. A possible reason is that $\hbar$ corresponds to Planck constant of dark Li which is much higher in living water. Hence the energies of dark photons do not induce microwave heating.

3. The visible light generated in the process has yellow color. The mundane explanation is that the introduction Na or its compounds into flame yields bright yellow color due to so called sodium D-lines [D7] at 588.9950 and 589.5924 nm emitted in transition from 3p to 3s level. Visible light could result as dark photons from the dropping of dark protons from dark space-time sheets of size at least atomic size to larger dark space-time sheets or to ordinary space-time sheets of same size and de-cohere to ordinary light. In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system.

   Yellow light corresponds roughly to the rather narrow energy range.96-2.1 eV ($.59-.63\ \mu m$). The metabolic quanta correspond to jumps to space-time sheets of increasing size give rise to the fractal series $E/eV = 2 \times (1 - 2^{-n})$ for transitions $k = 135 \to 135 + n$, $n = 1, 2, ...$ [K17]. For $n = 3, 4, 5$ the lines have energies $1.74, 1.87, 1.93$ eV and are in the visible red ($\lambda/\mu m = .71, .66, .64$). For $n > 5$ the color is yellow. In Kanarev's experiments the color is red which would mean the dominance of $n < 6$ lines: this color is regarded as a signature of the plasma electrolysis. In the burning of salt water the light is yellow [D1], which allows to consider the possibility that yellow light is partially due to $n > 5$ lines. Yellow color could also result from the dropping $k = 134 \to 135$ ($n = 1$).

4.2 Could Q-Laguerre Equation Relate To The Claimed Fractionation Of The Principal Quantum Number For Hydrogen Atom?

The so called hydrino atom concept of Randell Mills [D8] represents one of the notions related to free energy research not taken seriously by the community of university physicists. What is claimed that hydrogen atom can exists as scaled down variants for which binding energies are much higher than usually due to the large Coulomb energy. The claim is that the quantum number n having integer values $n = 0, 1, 2, 3..$ and characterizing partially the energy levels of the hydrogen atom

can have also inverse integer values $n = 1/2, 1/3, ...$ The claim of Mills is that the laboratory BlackLight Inc. led by him can produce a plasma state in which transitions to these exotic bound states can occur and liberate as a by-product usable energy.

The National Aeronautic and Space Administration has dispatched mechanical engineering professor Anthony Marchese from Rowan University to BlackLight's labs in Cranbury, NJ, to investigate whether energy plasmas-hot, charged gases- produced by Mills might be harnessed for a new generation of rockets. Marchese reported back to his sponsor, the NASA Institute for Advanced Concepts, that indeed the plasma was so far unexplainably energetic. An article about the findings of Mills and collaborators have been accepted for publication in Journal of Applied Physics so that there are reasons to take seriously the experimental findings of Mills and collaborators even if one does not take seriously the theoretical explanations.

The fractionized principal quantum number n claimed by Mills [D8] is reported to have at least the values $n = 1/k$, $k = 2, 3, 4, 5, 6, 7, 10$. First explanation would be in terms of Plack constant having also values smaller than $\hbar_0$ possible if singular factor spaces of causal diamond CD and CP_2 are allowed. q-Deformations of ordinary quantum mechanics are suggested strongly by the hierarchy of Jones inclusion associated with the hyper-finite factor of type II_1 about which WCW spinors are a basic example. This motivates the attempt to understand the claimed fractionization in terms of q-analog of hydrogen atom. The safest interpretation for them would be as states which can exist in ordinary imbedding space (and also in other branches)

The Laguerre polynomials appearing in the solution of Schrödinger equation for hydrogen atom possess quantum variant, so called q-Laguerre polynomials [**?**], and one might hope that they would allow to realize this semiclassical picture at the level of solutions of appropriately modified Schrödinger equation and perhaps also resolve the difficulty associated with $n = 1/2$. Unfortunately, the polynomials discussed in [**?**] correspond to $0 < q \leq 1$ rather than complex values of $q = exp(i\pi/m)$ on circle and the extrapolation of the formulas for energy eigenvalues gives complex energies.

4.2.1 q-Laquerre equation for $q = exp(i\pi/m)$

The most obvious modification of the Laguerre equation for S-wave sates (which are the most interesting by semiclassical argument) in the complex case is based on the replacement

$$\begin{aligned} \partial_x &\rightarrow \frac{1}{2}(\partial_x^{q)} + \partial_x^{\overline{q})}) \\ \partial_x^{q)} f &= \frac{f(qx) - f(x)}{(q-1)x} \quad , \\ q &= exp(i\pi/m) \end{aligned} \tag{4.1}$$

to guarantee hermiticity. When applied to the Laguerre equation

$$x\frac{d^2L_n}{dx^2} + (1-x)\frac{dL_n}{dx} = nL_n \quad , \tag{4.2}$$

and expanding L_n into Taylor series

$$L_n(x) = \sum_{n \geq 0} l_n x^n \quad , \tag{4.3}$$

one obtains difference equation

$$\begin{aligned} a_{n+1}l_{n+1} + b_n l_n &= 0 \quad , \\ a_{n+1} &= \frac{1}{4R_1^2}\left[R_{2n+1} - R_{2n} + 2R_{n+1}R_1 + 3R_1)\right] + \frac{1}{2R_1}\left[R_{n+1} + R_1\right] \\ b_n &= \frac{R_n}{2R_1} - n^{q)} + \frac{1}{2} \quad , \\ R_n &= 2cos\left[(n-1)\pi/m\right] - 2cos\left[n\pi/m\right] \quad . \end{aligned} \tag{4.4}$$

Here $n^{q)}$ is the fractionized principal quantum number determining the energy of the q-hydrogen atom. One cannot pose the difference equation on l_0 since this together with the absence of negative powers of x would imply the vanishing of the entire solution. This is natural since for first order difference equations lowest term in the series should be chosen freely.

4.2.2 Polynomial solutions of q-Laquerre equation

The condition that the solution reduces to a polynomial reads as

$$b_n = 0 \tag{4.5}$$

and gives

$$n^{q)} = \frac{1}{2} + \frac{R_n}{2R_1} \ , \tag{4.6}$$

For $n = 1$ one has $n^{q)} = 1$ so that the ground state energy is not affected. At the limit $N \to \infty$ one obtains $n^{q)} \to n$ so that spectrum reduces to that for hydrogen atom. The periodicity $R_{n+2Nk} = R_n$ reflects the corresponding periodicity of the difference equation which suggests that only the values $n \leq 2m-1$ belong to the spectrum. Spectrum is actually symmetric with respect to the middle point $[N/2]$ which suggests that only $n < [m/2]$ corresponds to the physical spectrum. An analogous phenomenon occurs for representations of quantum groups [K2]. When m increases the spectrum approaches integer valued spectrum and one has $n > 1$ so that no fractionization in the desired sense occurs for polynomial solutions.

4.2.3 Non-polynomial solutions of q-Laquerre equation

One might hope that non-polynomial solutions associated with some fractional values of $n^{q)}$ near to those claimed by Mills might be possible. Since the coefficients a_n and b_n are periodic, one can express the solution ansatz as

$$\begin{aligned} L_n(x) &= P_a^{2m)}(x) \sum_k a^k x^{2mk} = P_a^{2m)}(x) \frac{1}{1-ax^{2m}} \ , \\ P_a^{2m)}(x) &= \sum_{k=0}^{2m-1} l_k x^k \ , \\ a &= \frac{l_{2m}}{l_0} \ , \end{aligned} \tag{4.7}$$

This solution behaves as $1/x$ asymptotically but has pole at $x_\infty = (1/a)^{1/2m}$ for $a > 0$.

The expression for $l_{2m}/l_0 = a$ is

$$a = \prod_{k=1}^{2m} \frac{b_{2m-k}}{a_{2m-k+1}} \ . \tag{4.8}$$

This can be written more explicitly as

$$\begin{aligned} a &= (2R_1)^{2m} \prod_{k=1}^{2m} X_k \ , \\ X_k &= \frac{R_{2m-k} + (-2n^{q)} + 1)R_1}{R_{4m-2k+1} - R_{4m-2k} + 4R_{2m-k+1}R_1 + 2R_1^2 + 3R_1} \ , \\ R_n &= 2cos\left[(n-1)\pi/m\right] - 2cos\left[n\pi/m\right] \ . \end{aligned} \tag{4.9}$$

This formula is a specialization of a more general formula for $n = 2m$ and resulting ratios l_n/l_0 can be used to construct $P_a^{2m)}$ with normalization $P_a^{2m)}(0) = 1$.

Table 5: Table gives the approximations $1/n^{q)}_{\simeq} = 1/k$ and corresponding exact values $1/n^{q)}$ in the range $k = 3, ..., 10$ for which $P_a^{2m)}(x_\infty)$ is nearest to zero. The corresponding values of $m = 2k$ vary in the range, $k = 18, ..., 38$. For odd values of m the value of the parameter a is negative so that there is no pole. Boldface marks for the best approximation by $1/n^{q)}_{\simeq} = k$.

m	$1/n^{q)}_{\simeq}$	$1/n^{q)}$	m	$1/n^{q)}_{\simeq}$	$1/n^{q)}$
18	**3**	2.7568	30	8	7.5762
20	**4**	3.6748	**32**	**8**	8.3086
22	5	4.5103	**34**	**9**	9.0342
24	**5**	5.3062	**36**	**10**	9.7529
26	**6**	6.0781	38	10	10.4668
28	**7**	6.8330			

4.2.4 Results of numerical calculations

Numerical calculations demonstrate following.

1. For odd values of m one has $a < 0$ so that a a continuous spectrum of energies seems to result without any further conditions.

2. For even values of m a has a positive sign so that a pole results.

For even value of m it could happen that the polynomial $P_a^{2m)}(x)$ has a compensating zero at x_∞ so that the solution would become square integrable. The condition for reads explicitly

$$P_a^{2m)}\left((\frac{1}{a})^{\frac{1}{2m}}\right) \quad = \quad 0 \ . \tag{4.10}$$

If $P_a^{2m)}(x)$ has zeros there are hopes of finding energy eigen values satisfying the required conditions. Laguerre polynomials and also q-Laguerre polynomials must posses maximal number of real zeros by their orthogonality implied by the hermiticity of the difference equation defining them. This suggests that also $P_a^{2m)}(x)$ possesses them if a does not deviate too much from zero. Numerical calculations demonstrate that this is the case for $n^{q)} < 1$.

For ordinary Laguerre polynomials the naive estimate for the position of the most distant zero in the units used is larger than n but not too much so. The naive expectation is that L_{2m} has largest zero somewhat above $x = 2m$ and that same holds true a small deformation of L_{2m} considered now since the value of the parameter a is indeed very small for $n^{q)} < 1$. The ratio $x_\infty/2m$ is below .2 for $m \leq 10$ so that this argument gives good hopes about zeros of desired kind.

One can check directly whether x_∞ is near to zero for the experimentally suggested candidates for $n^{q)}$. **Table 5** summarizes the results of numerical calculations.

1. **Table 5** gives the exact eigenvalues $1/n_{q)}$ with a 4-decimal accuracy and corresponding approximations $1/n^{q)}_{\simeq} = k$ for $k = 3, ..., 10$. For a given value of m only single eigenvalue $n^{q)} < 1$ exists. If the observed anomalous spectral lines correspond to single electron transitions, the values of m for them must be different. The value of m for which $n^{q)} \simeq 1/k$ approximation is optimal is given with boldface. The value of k increases as m increases. The lowest value of m allowing the desired kind of zero of $P^{2m)}$ is $m = 18$ and for $k \in \{3, 10\}$ the allowed values are in range $18, .., 38$.

2. $n^{q)} = 1/2$ does not appear as an approximate eigenvalue so that for even values of m quantum calculation produces same disappointing result as the classical argument. Below it will be however found that $n^{q)} = 1/2$ is a universal eigenvalue for odd values of m.

4.2.5 How to obtain $n^{q)} = 1/2$ state?

For odd values of m the quantization recipe fails and physical intuition tells that there must be some manner to carry out quantization also now. The following observations give a hunch about the desired condition.

1. For the representations of quantum groups only the first m spins are realized [K2]. This suggests that there should exist a symmetry relating the coefficients l_n and l_{n+m} and implying $n^{q)} = 1/2$ for odd values of m. This symmetry would remove also the double degeneracy associated with the almost integer eigenvalues of $n^{q)}$. Also other fractional states are expected on basis of physical intuition.

2. For $n^{q)} = 1/2$ the recursion formula for the coefficients l_n involves only the coefficients R_m.

3. The coefficients R_k have symmetries $R_k = R_{k+2m}$ and $R_{k+m} = -R_m$.

There is indeed this kind of symmetry. From the formula

$$\begin{aligned} \frac{l_n}{l_0} &= (2R_1)^n \prod_{k=1}^{n} X_k \ , \\ X_k &= \frac{R_{n-k} + (-2n^{q)} + 1)R_1}{[R_{2n-2k+1} - R_{n-2k} + 4R_{n-k+1}R_1 + 2R_1^2 + 3R_1} \end{aligned} \tag{4.11}$$

one finds that for $n^{q)} = 1/2$ the formula giving l_{n+m} in terms of l_n changes sign when n increases by one unit

$$\begin{aligned} A_{n+1} &= (-1)^m A_n \ , \\ A_n &= \prod_{k=1}^{m} \frac{b_{n+m-k}}{a_{n+m-k+1}} = \prod_{k=1}^{m} (2R_1)^m \prod_{k=1}^{m} X_{k+n} \ . \end{aligned} \tag{4.12}$$

The change of sign is essentially due to the symmetries $a_{n+m} = -a_n$ and $b_{n+m} = b_n$. This means that the action of translations on A_n in the space of indices n are represented by group Z_2.

This symmetry implies $a = l_{2m}/l_0 = -(l_m)(l_0)^2$ so that for $n^{q)} = 1/2$ the polynomial in question has a special form

$$\begin{aligned} P_a^{2m)} &= P_a^{m)}(1 - Ax^m) \ , \\ A &= A_0 \ . \end{aligned} \tag{4.13}$$

The relationship $a = -A^2$ implies that the solution reduces to a form containing the product of m^{th} (rather than $(2m)^{th}$) order polynomial with a geometric series in x^m (rather than x^{2m}):

$$L_{1/2}(x) = \frac{P_a^{m)}(x)}{1 + Ax^m} \ . \tag{4.14}$$

Hence the n first terms indeed determine the solution completely. For even values of m one obtains similar result for $n^{q)} = 1/2$ but now A is negative so that the solution is excluded. This result also motivates the hypothesis that for the counterparts of ordinary solutions of Laguerre equation sum (even m) or difference (odd m) of solutions corresponding to n and $2m - n$ must be formed to remove the non-physical degeneracy.

This argument does not exclude the possibility that there are also other fractional values of n allowing this kind of symmetry. The condition for symmetry would read as

$$\begin{aligned}\prod_{k=1}^{m}(R_k+\epsilon R_1) &= \prod_{k=1}^{m}(R_k-\epsilon R_1)\ ,\\ \epsilon &= (2n^{q)}-1\ .\end{aligned} \tag{4.15}$$

The condition states that the odd part of the polynomial in question vanishes. Both ϵ and $-\epsilon$ solutions so that $n^{q)}$ and $1-n^{q)}$ are solutions. If one requires that the condition holds true for all values of m then the comparison of constant terms in these polynomials allows to conclude that $\epsilon = 0$ is the only universal solution. Since ϵ is free parameter, it is clear that the m: th order polynomial in question has at most m solutions which could correspond to other fractionized eigenvalues expected to be present on basis of physical intuition.

This picture generalizes also to the case of even n so that also now solutions of the form of Eq. 4.14 are possible. In this case the condition is

$$\prod_{k=1}^{m}(R_k+\epsilon R_1) = -\prod_{k=1}^{m}(R_k-\epsilon R_1)\ . \tag{4.16}$$

Obviously $\epsilon = 0$ and thus $n = 1/2$ fails to be a solution to the eigenvalue equation in this case. Also now one has the spectral symmetry $n_\pm = 1/2 \pm \epsilon$.

The symmetry $R_n = (-1)^m R_{n+m-1} = (-1)^m R_{n-m-1} = (-1)^m R_{m-n+1}$ can be applied to show that the polynomials associated with ϵ and $-\epsilon$ contain both the terms $R_n - \epsilon$ and $R_n + \epsilon$ as factors except for odd m for $n = (m+1)/2$. Hence the values of n can be written for even values of m as

$$n^{q)}(n) = \frac{1}{2} \pm \frac{R_n}{2R_1}\ ,\ n = 1, ..., \frac{m}{2}\ , \tag{4.17}$$

and for odd values of m as

$$\begin{aligned} n^{q)}_\pm(n) &= \frac{1}{2} \pm \frac{R_n}{2R_1}\ ,\ n = 1, ..., \frac{m+1}{2} - 1\ ,\\ n^{q)} &= 1/2\ .\end{aligned} \tag{4.18}$$

Plus sign obviously corresponds to the solutions which reduce to polynomials and to $n^{q)} \simeq n$ for large m. The explicit expression for $n^{q)}$ reads as

$$n^{q)}_\pm(n) = \frac{1}{2} \pm \frac{(sin^2(\pi(n-1)/2m) - sin^2(\pi n/2m))}{2sin^2(\pi/2m)}\ . \tag{4.19}$$

At the limit of large m one has

$$n^{q)}_+(n) \simeq n\ ,\ n^{q)}_-(n) \simeq 1-n\ . \tag{4.20}$$

so that the fractionization $n \simeq 1/k$ claimed by Mills is not obtained at this limit. The minimum for $|n^{q)}|$ satisfies $|n^{q)}| < 1$ and its smallest value $|n^{q)}| = .7071$ corresponds to $m = 4$. Thus these zeros cannot correspond to $n^{q)} \simeq 1/k$ yielded by the numerical computation for even values of m based on the requirement that the zero of $P^{2m)}$ cancels the pole of the geometric series.

4.2.6 Some comments

Some closing comments are in order.

1. An open question is whether there are also zeros $|n^{q)}| > 1$ satisfying $P_a^{2m)}((1/a)^{1/2m}) = 0$ for even values of m.

2. The treatment above is not completely general since only s-waves are discussed. The generalization is however a rather trivial replacement $(1-x)d/dx \to (l+1-x)d/dx$ in the Laguerre equation to get associated Laguerre equation. This modifies only the formula for a_{n+1} in the recursion for l_n so that expression for $n^{q)}$, which depends on b_n: s only, is not affected. Also the product of numerators in the formula for the parameter $a = l_{2m}/l_0$ remains invariant so that the general spectrum has the spectral symmetry $n^{q)} \to 1 - n^{q)}$. The only change to the spectrum occurs for even values of m and is due to the dependence of $x_\infty = (1/a)^{1/2m}$ on l and can be understood in the semiclassical picture. It might happen that the value of l is modified to its q counterpart corresponding to q-Legendre functions.

3. The model could partially explain the findings of Mills and $n^{q)} \simeq 1/k$ for $k > 2$ also fixes the value of corresponding m to a very high degree so that one would have direct experimental contact with generalized imbedding space, spectrum of Planck constants, and dark matter. The fact that the fractionization is only approximately correct suggests that the states in question could be possible for all sectors of imbedding space appear as intermediate states into sectors in which the spectrum of hydrogen atom is scaled by $n_b/n_a = k = 2, 3, ...$

4. The obvious question is whether q-counterparts of angular momentum eigenstates ($idf_m/d\phi = mf_m$) are needed and whether they make sense. The basic idea of construction is that the phase transition changing $\hbar$ does not involve any other modifications except fractionization of angular momentum eigenvalues and momentum eigenvalues having purely geometric origin. One can however ask whether it is possible to identify q-plane waves as ordinary plane waves. Using the definition $L_z = 1/2(\partial_u^q + \partial_u^{\overline{q}})$, $u = exp(i\phi)$, one obtains $f_n = exp(in\phi)$ and eigenvalues as $n^{q)} = R_n/R_1 \to n$ for $m \to \infty$. Similar construction applies in the case of momentum components.

4.3 Comparison With The Reports About Biological Transmutations

Kervran's book "Biological Transmutations" [C11] contains a surprisingly detailed summary about his work with biological transmutations and it is interesting to find whether the proposed model could explain the findings of Kervran. TGD suggests two general mechanisms.

1. The nuclear reactions involving dark Li, C, and F predicted to be present in living matter.

2. Nuclear fusions made possible by a temporary transformation of ordinary nuclear space-time sheets to dark ones with much larger size so that Coulomb wall is reduced considerably. The nuclear reaction might proceed if it is energetically possible. Almost any reaction $A+B \to C$ is possible via this mechanism unless the nuclei are not too heavy.

4.3.1 Fortuitous observations

In his childhood Kervran started to wonder why hens living in a limestone poor region containing thus very little calcium in ground and receiving no calcium in their nutrition could develop the calcium required by eggs and by their own bones. He noticed that hens had the habit of eating mica, which contains silicon. Later this led to the idea that Si could somehow transmute to Ca in living matter. In the proposed model this could correspond to fusion of $Si(14,14)+\mathbf{C}(\mathbf{6},\mathbf{6}) \to Ca(20,20)$ which occurs spontaneously.

Second fortuitous observation were the mysterious CO poisonings by welders working in factory. After careful studies Kervran concluded that CO must be produced endogenously and proposed that the inhaled air which had been in contact with incandescent iron induces the transformation $N_2 \to CO$ conserving both neuron and neutron number. This transformation might be understood in TGD context if the nuclear space-time sheets are part of time in dark with much larger size so that a direct contact becomes possible for nuclear space-time sheets and Coulomb wall is reduced so that the reaction can proceed with some probability if energetically possible. The thermal energy received from hot iron might help to overcome the Coulomb barrier. The mass difference $m(2N) - m(O) - m(C) = 10.45$ MeV allows this reaction to occur spontaneously.

4.3.2 Examples of various anomalies

Kervran discusses several plant anomalies. The ashes of plants growing in Si rich soil contain more Ca than they should: this transmutation has been already discussed. The ashes of a plant growing on Cu fibres contain no copper but 17 per cent of iron oxides in addition to other elements which could not have come from the rain water. The reaction $Cu(58) + \mathbf{Li}(\mathbf{3},\mathbf{4}) \to Fe(26,32) + \mathbf{C}(\mathbf{6},\mathbf{6})$ would liberate energy of 11.5 MeV.

There are several mineral anomalies.

1. Dolomite rock is formed inside limestone rocks which would suggest the transmutation of $Ca(20,20)$ into $Mg(12,12)$. The nuclear reaction $Ca(20,20) + \mathbf{Li}(\mathbf{3},\mathbf{4}) \to Mg(12,12) + Na(11,12)$ would liberate energy of 3.46 MeV. Ca emerges from Si in soil and in what Kervran refers to a "sickness of stone". The candidate reaction has been already discussed.

2. Graphite is found in siliceous rocks. Kervran proposes the reaction $Si \to C + O$. $m(Si) - m(C) - M(O) = -16.798$ MeV does not allow this reaction to proceed spontaneously but the reaction $Si + \mathbf{Li} \to C + Na$ liberates the energy 2.8880 MeV.

3. Kervran mentions the reaction $O + O \to S$ as a manner to produce sulphur from oxygen. This reaction is obviously energetically favored.

Kervran discusses the transmutations $Na \to K$ and $Na \to Ca$ occurring also in plasma electrolysis and explained by TGD based model. Further transmutations are $Na \to Mg$ and $Mg \to Ca$. $Na \to Mg$ could correspond to the reaction $Na(11,12) + \mathbf{Li}(\mathbf{3},\mathbf{2}) \to Mg(12,12) + He(2,2)$ favored by the high binding energy per nucleon for ^4He (7.072 MeV). $Mg \to Ca$ would correspond to the reaction $Mg + O \to Ca$, which obviously liberates energy.

4.4 Are The Abundances Of Heavier Elements Determined By Cold Fusion In Interstellar Medium?

According to the standard model, elements not heavier than Li were created in Big Bang. Heavier elements were produced in stars by nuclear fusion and ended up to the interstellar space in supernova explosions and were gradually enriched in this process. Lithium problem forces to take this theoretical framework with a grain of salt.

The work of Kervran [C11] suggests that cold nuclear reactions are occurring with considerable rates, not only in living matter but also in non-organic matter. Kervran indeed proposes that also the abundances of elements at Earth and planets are to high degree determined by nuclear transmutations and discusses some examples. For instance, new mechanisms for generation of O and Si would change dramatically the existing views about evolution of planets and prebiotic evolution of Earth.

4.4.1 Where did the Lithium go?

Ulla - one of the commentators in my blog - sent an interesting link concerning Lithium problem to an article by Elisabetta Caffau et al titled "An extremely primitive halo star" [E4].

What has been found is a star which is extremely poor on metallic elements: ("metallic" refers to elements heavier than Li). The mystery is that not only elements heavier than Li but also Li itself, whose average abundance is believed to be determined by cosmological rather than stellar nucleosynthesis, is very scarcely present in these stars.

This finding can be coupled with too other observations about anomalies in Li abundance.

1. The average abundance of Li in Cosmos is lower than predicted by standard cosmology by a factor between 2 and 3 [E2].

2. Also Sun has too low Li abundance [E1].

Authors think that some process could have created very high temperature destroying the Li in this kind of stars: maybe dark matter annihilation might have caused this. This looks rather artificial to me and would not explain too low Li abundance for other stars and for interstellar medium.

Table 6: Table gives the most abundant isotopes of stable nuclei.

H(1, 0)							He(2, 2)
Li(3, 4)	Be(4, 5)	B(5, 6)	C(6, 6)	N(7, 7)	O(8, 8)	F(9, 10)	Ne(10, 10)
Na(11, 12)	Mg(12, 12)	Al(13, 14)	Si(14, 14)	P(15, 16)	S(16, 16)	Cl(17, 18)	A(18, 22)
K(19, 20)	Ca(20, 20)						

The transformation of Li to dark matter (ordinary Lithium in a phase with larger value of Planck constant) would mean its effective disappearance. This process would have occurred both in interstellar medium and in stars so that all three Li problems would be solved at once. Many question marks remain. What about the rate for the phase transition to dark matter? Also lighter elements should be able to transform to dark form. Why the cosmological abundances for them are however essentially those predicted by the standard model of primordial nucleosynthesis? Is the reason that Li their fusion to Li was much faster than transformation to dark matter during primordial nucleosynthesis whereas Li fused very slowly and had time to transform to dark Li?

Li problem would rather sharply distinguish between two very different views about dark matter: dark matter as some exotic elementary particles on one hand and dark matter as phases of ordinary matter implied by generalization of quantum theory on the other hand.

4.4.2 Are heavier nuclei produced in the interstellar space?

TGD based model is consistent with the findings of Kervran and encourages to a consider a simple model for the generation of heavier elements in interstellar medium. The assumptions are following.

1. Dark nuclei $X(3k, n)$, that is nuclear strings of form $Li(3, n)$, $C(6, n)$, $F(9, n)$, $Mg(12, n)$, $P(15, n)$, $A(18, n)$, etc..., form as a fusion of Li strings. $n = Z$ is the most plausible value of n. There is also ^4He present but as a noble gas it need not play an important role in condensed matter phase (say interstellar dust). The presence of water necessitates that of $Li(3, n)$ if one accepts the proposed model as such.

2. The resulting nuclei are in general stable against spontaneous fission by energy conservation. The binding energy of $He(2, 2)$ is however exceptionally high so that alpha decay can occur in dark nuclear reactions between $X(3k, n)$ allowed by the considerable reduction of the Coulomb wall. The induced fissions $X(3k, n) \to X(3k - 2, n - 2) + He(2, 2)$ produces nuclei with atomic number $Z \ mod \ 3 = 1$ such as $Be(4, 5)$, $N(7, 7)$, $Ne(10, 10)$, $Al(13, 14)$, $S(16, 16)$, $K(19, 20)$, ... Similar nuclear reactions make possible a further alpha decay of $Z \ mod \ 3 = 1$ nuclei to give nuclei with $Z \ mod \ 2$ such as $B(5, 6)$, $O(8, 8)$, $Na(11, 12)$, $Si(14, 14)$, $Cl(17, 18)$, $Ca(20, 20)$, ... so that most stable isotopes of light nuclei could result in these fissions.

3. The dark nuclear fusions of already existing nuclei can create also heavier Fe. Only the gradual decrease of the binding energy per nucleon for nuclei heavier than Fe poses restrictions on this process.

Table 6 allows the reader to build a more concrete view about how the heavier nuclei might be generated via the proposed mechanisms.

4.4.3 The abundances of nuclei in interstellar space should not depend on time

The basic prediction of TGD inspired model is that the abundances of the nuclei in the interstellar space should not depend on time if the rates are so high that equilibrium situation is reached rapidly. The $\hbar$ increasing phase transformation of the nuclear space-time sheet determines the time scale in which equilibrium sets on. Standard model makes different prediction: the abundances of the heavier nuclei should gradually increase as the nuclei are repeatedly re-processed in stars and blown out to the interstellar space in super-nova explosion.

Amazingly, there is empirical support for this highly non-trivial prediction [E6]. Quite surprisingly, the 25 measured elemental abundances (elements up to $Sn(50, 70)$ (tin) and $Pb(82, 124)$ (lead)) of a 12 billion years old galaxy turned out to be very nearly the same as those for Sun. For instance, oxygen abundance was 1/3 from that from that estimated for Sun. Standard model

would predict that the abundances should be.01-.1 from that for Sun as measured for stars in our galaxy. The conjecture was that there must be some unknown law guaranteeing that the distribution of stars of various masses is time independent. The alternative conclusion would be that heavier elements are created mostly in interstellar gas and dust.

4.4.4 Could also "ordinary" nuclei consist of protons and negatively charged color bonds?

The model would strongly suggest that also ordinary stable nuclei consist of protons with proton and negatively charged color bond behaving effectively like neutron. Note however that I have also consider the possibility that neutron halo consists of protons connected by negatively charged color bonds to main nucleus. The smaller mass of proton would favor it as a fundamental building block of nucleus and negatively charged color bonds would be a natural manner to minimizes Coulomb energy. The fact that neutron does not suffer a beta decay to proton in nuclear environment provided by stable nuclei would also find an explanation.

1. Ordinary shell model of nucleus would make sense in length scales in which proton plus negatively charged color bond looks like neutron.

2. The strictly nucleonic strong nuclear isospin is not vanishing for the ground state nuclei if all nucleons are protons. This assumption of the nuclear string model is crucial for quantum criticality since it implies that binding energies are not changed in the scaling of $\hbar$ if the length of the color bonds is not changed. The quarks of charged color bond however give rise to a compensating strong isospin and color bond plus proton behaves in a good approximation like neutron.

3. beta decays might pose a problem for this model. The electrons resulting in beta decays of this kind nuclei consisting of protons should come from the beta decay of the d-quark neutralizing negatively charged color bond. The nuclei generated in high energy nuclear reactions would presumably contain genuine neutrons and suffer beta decay in which d quark is nucleonic quark. The question is whether how much the rates for these two kinds of beta decays differ and whether existing facts about beta decays could kill the model.

5 Cold Fusion And Sonoluminescence

5.1 Basic Ideas About Cold Fusion

The basic prediction of TGD is a hierarchy of fractally scaled variants of QCD like theories and that color dynamics is fundamental even for our sensory qualia (visual colors identified as increments of color quantum numbers in quantum jump). The model for ORMEs suggest that exotic protons obey QCD like theory in the size scale of atom. If this identification is correct, QCD like dynamics might be studied some day experimentally in atomic or even macroscopic length scales of order cell size and there would be no need for ultra expensive accelerators!

5.1.1 What makes possible cold fusion?

I have proposed that cold fusion might be based on Trojan horse mechanism in which incoming and target nuclei feed their em gauge fluxes to different space-time sheets so that electromagnetic Coulomb wall disappears [K21]. If part of Palladium nuclei are "partially dark", this is achieved. Another mechanism could be the de-localization of protons to a larger volume than nuclear volume induced by the increase of h_{eff} meaning that reaction environment would differ dramatically from that appearing in the usual nuclear reactions and the standard objections against cold fusion would not apply anymore [K21]: this de-localization could correspond to the darkness of electromagnetic and perhaps also electroweak field bodies of protons.

A third proposal is perhaps the most elegant and relies on the nuclear string model [K15] predicting a large number of exotic nuclei obtained by allowing the color bonds connecting nucleons to have all possible em charges $1, 0, 1$. Many ordinary heavy nuclei would be exotic in the sense that some protons would correspond to protons plus negatively charged color bonds. The exchange

of an exotic weak boson between D and Pd nuclei transforming D nuclei to exotic neutral D nuclei would occur. The range of the exotic weak interaction correspond to atomic length scale meaning that it behaves as massless particle below this length scale. For instance, W boson could be $r = 2^{24}$ dark variant of $k = 113$ weak boson for which the dark variant of p-adic scale would correspond to the atomic scale $k = 137$ but also other options are possible.

5.1.2 How standard objections against cold fusion can be circumvented?

The following arguments against cold fusion are from an excellent review article by Storms [C13].

1. Coulomb wall requires an application of higher energy. Now electromagnetic Coulomb wall disappears in both models.

2. If a nuclear reaction should occur, the immediate release of energy can not be communicated to the lattice in the time available. In the recent case the time scale is however multiplied by the factor $r = n_a$ and the situation obviously changes. For $n_a = 2^{24}$ the time scale corresponding to MeV energy becomes that corresponding to keV energy which is atomic time scale.

3. When such an energy is released under normal conditions, energetic particles are emitted along with various kinds of radiation, only a few of which are seen by various CANR (Chemically Assisted Nuclear Reactions) studies. In addition, gamma emission must accompany helium, and production of neutrons and tritium, in equal amounts, must result from any fusion reaction. None of these conditions is observed during the claimed CANR effect, no matter how carefully or how often they have been sought. The large value of $\hbar(M^4)$ implying large Compton lengths for protons making possible geometric coupling of gamma rays to condensed matter would imply that gamma rays do not leave the system. If only protons form the quantum coherent state then fusion reactions do not involve the protons of the catode at all and production of ^3He and thus of neutrons in the fusion of D and exotic D.

4. The claimed nuclear transmutation reactions (reported to occur also in living matter [C10]) are very difficult to understand in standard nuclear physics framework.

   (a) The model of [K21] allows them since protons of different nuclei can re-arrange in many different manners when the dark matter state decays back to normal.

   (b) Nuclear string model [K15] allows transmutations too. For instance, neutral exotic tritium produced in the reactions can fuse with Pd and other nuclei.

5. Many attempts to calculate fusion rates based on conventional models fail to support the claimed rates within PdD (Palladium-Deuterium). The atoms are simply too far apart. This objections also fails for obvious reasons.

5.1.3 Mechanisms of cold fusion

In TGD framework exotic nuclei are needed to explain the selection rules which do not conform with standard nuclear physics. There are several options for what exotic nuclei could be.

1. Nuclei might be partially dark with some nucleons in dark state with Compton length of order atomic length scale.

2. Nuclei can also be exotic in the sense that some neutral color bonds have transformed to charged ones by exchange of dark W bosons effectively massless below atomic length scale. This could transform D nuclei to neutral ones and eliminate Coulomb wall. The presence of two oppositely charged bonds by (possibly dark) W exchange could give rise to a nucleus with same em charge as the original but different mass: presumably mass difference would be of order keV.

3. Also the emitted em radiation - say gamma rays - and particles - say protons or neutrons - could be dark and could remain undetected using standard means.

From this it is clear that it easy to invent models consistent with observations: careful consideration of data might however allow to fix the model to a high degree. One can try to deduce a more detailed model for cold fusion from observations, which are discussed systematically in [C13] and in the references discussed therein.

1. A critical phenomenon is in question. The average D/Pd ratio must be in the interval $(.85, .90)$. The current must be over-critical and must flow a time longer than a critical time. The effect occurs in a small fraction of samples. D at the surface of the catode is found to be important and activity tends to concentrate in patches. The generation of fractures leads to the loss of the anomalous energy production. Even the shaking of the sample can have the same effect. The addition of even a small amount of H_2O to the electrolyte (protons to the catode) stops the anomalous energy production.

   (a) These findings are consistent the view that patches correspond to a macroscopic quantum phase involving de-localized nuclear protons. The added ordinary protons and fractures could serve as a seed for a phase transition leading to the ordinary phase [K21].

   (b) An alternative interpretation is in terms of the formation of neutral exotic D and exotic Pd via exchange of exotic, possibly dark, W bosons massless below atomic length scale [K15].

2. When D_2O is used as an electrolyte, the process occurs when PdD acts as a catode but does not seem to occur when it is used as anode. This suggests that the basic reaction is between the ordinary deuterium $D = pn$ of electrolyte with the exotic nucleus of the catode. Denote by $\hat{p}$ the exotic proton and by $\hat{D} = n\hat{p}$ exotic deuterium at the catode.

   For ordinary nuclei fusions to tritium and ^3He occur with approximately identical rates. The first reaction produces neutron and ^3He via $D + D \to n +^3 He$, whereas second reaction produces proton and tritium by $3H$ via $D + D \to p +^3 H$. The prediction is that one neutron per each tritium nucleus should be produced. Tritium can be observed by its beta decay to ^3He and neutron flux is several orders of magnitude smaller than tritium flux as found for instance by Tadahiko Mizuno and his collaborators (Mizuno describes the experimental process leading to this discovery in his book [C17]). Hence the reaction producing ^3He cannot occur significantly in cold fusion which means a conflict with the basic predictions of the standard nuclear physics.

   (a) The explanation discussed in [K21] does not involve exotic nuclei with charged color bonds. The assumption is that the proton in the target deuterium $\hat{D}$ is in the exotic state with large Compton length and the production of ^3He occurs very slowly since $\hat{p}$ and p correspond to different space-time sheets. Since neutrons and the proton of the D from the electrolyte are in the ordinary state, Coulomb barrier is absent and tritium production can occur. The mechanism also explains why the cold fusion producing ^3He and neutrons does not occur using water instead of heavy water.

   (b) Nuclear string model [K15] model with charged color bonds predicts that only neutral exotic tritium is produced considerably when incoming deuterium interacts with neutral exotic deuterium in the target. This requires that in target D nuclei exchange large $\hbar$ W boson with electron or Pd or other D nucleus. In the latter case the outcome is two exotic nuclei looking chemically like di-neutron and ^3He.

3. The production of ^4He has been reported although the characteristic gamma rays have not been detected.

   (a) ^4He can be produced in reactions such as $D + \hat{D} \to^4 He$ or its exotic counterpart in the model of [K21].

   (b) Nuclear string model [K21] does not allow direct production of ^4He in D-D collisions.

4. Also more complex reactions between D and Pd for which protons are in exotic state, can occur. These can lead to the reactions transforming the nuclear charge of Pd and thus to nuclear transmutations.

Both models allow nuclear transmutations. In nuclear string model [K21] the resulting exotic tritium can fuse with Pd and other nuclei and produce nuclear transmutations.

The reported occurrence of nuclear transmutation such as $^{23}Na+^{16}O \rightarrow^{39} K$ in living matter [C10] allowing growing cells to regenerate elements K, Mg, Ca, or Fe, could be understood in nuclear string model if also neutral exotic charge states are possible for nuclei in living matter. The experimental signature for the exotic ions would be cyclotron energy spectrum containing besides the standard lines also lines with ions with anomalous mass number. This could be seen as a splitting of lines. For instance, exotic variants of ions such Na^+, K^+, Cl^-, Ca^{++} with anomalous mass numbers should exist. It would be easy to mis-interpret the situation unless the actual strength of the magnetic field is not checked.

5. Gamma rays, which should be produced in most nuclear reactions such as ^4He production to guarantee momentum conservation are not observed.

   (a) The explanation of the model of [K21] is that the recoil momentum goes to the macroscopic quantum phase and eventually heats the electrolyte system. This provides obviously the mechanism by which the liberated nuclear energy is transferred to the electrolyte difficult to imagine in standard nuclear physics framework. The emitted gamma rays could be also dark and observed only if they transform to ordinary ones.

   (b) In nuclear string model [K15] ^4He is not produced at all.

6. Both models explain why neutrons are not produced in amounts consistent with the anomalous energy production. The addition of water to the electrolyte is however reported to induce neutron bursts.

   (a) In the model of [K21] (no charged color bonds) a possible mechanism is the production of neutrons in the phase transition $\hat{p} \rightarrow p$. $\hat{D} \rightarrow p + n$ could occur as the proton contracts back to the ordinary size in such a manner that it misses the neutron. This however requires energy of 2.23 MeV if the rest masses of $\hat{D}$ and D are same. Also $\hat{D} + \hat{D} \rightarrow n +^3 He$ could be induced by the phase transition to ordinary matter when $\hat{p}$ transformed to p does not combine with its previous neutron partner to form D but recombines with $\hat{D}$ to form $^3\hat{He} \rightarrow^3 He$ so that a free neutron is left.

   (b) Nuclear string model [K15] would suggest that the collisions of protons of water with exotic neutral D with negatively charged color bond produce neutron and ordinary D. This requires the transformation of negatively charged color bond between p and n of target D to a neutral color bond between incoming p and neutron of target.

A cautious conclusion is that nuclear string model with exotic color bonds and dark weak bosons is the more natural option. Also dark protons suggested strongly by the model for the dark portion of water can be considered but partial darkness of nuclei is perhaps an artificial idea. Note that all nuclei might appear as dark variants with size scale of molecules and analogous to folded proteins. This intriguing similarity creates the question whether the physics of linear biomolecules mimics nuclear physics and whether dark nuclei are involved with this mimicry natural in the fractal Universe of TGD.

5.2 Does Rossi's Reactor Give Rise To Cold Fusion?

Lubos Motl has been raging several times about the cold fusion gadget of Andrea Rossi and I decided to write the following response as he returned to the topic again. The claim of Rossi and physicist Fogardi [C18] is that the cold fusion reaction of H and Ni producing Cu takes place in the presence of some "additives" (Palladium catalyst as in may cold fusion experiments gathering at its surface Ni?).

5.2.1 Objections claiming that the evaporation of water does not actually take place

Lubos Motl of course "knows" before hand that the gadget cannot work: Coulomb barrier. Since Lubos Motl is true believer in naive text book wisdom, he simply refuses to consider the possibility

that the physics that we learned during student days might not be quite right. Personally I do not believe or disbelieve cold fusion: I just take it seriously as any person calling himself scientist should do. I have been developing for more than 15 years ideas about possible explanation of cold fusion in TGD framework. The most convincing idea is that large value of Planck constant associated with nuclei could be involved scaling up the range of weak interactions from 10^{-17} meters to atomic size scale and also scaling up the size of nucleus to atomic size scale so that nucleus and even quarks would like constant charge densities instead of point like charge. Therefore Coulomb potential would be smoothed and the wall would become much lower (see this and this) [K21, K15].

One must say in honor of Lubos Motl that at this time he had detailed arguments about what goes wrong with the reactor of Rossi: this is in complete contrast with the usual arguments of skeptics which as a rule purposefully avoid saying anything about the actual content and concentrate on ridiculing the target. The reason is of course that standard skeptic is just a soldier who has got the list of targets to be destroyed and as a good soldier does his best to achieve the goal. Thinking is not what a good soldier is expected to do since the professors in the consultive board take care of this and give orders to those doing the dirty job.

As a theoretician I have learned the standard arguments used to debunk TGD: logic is circular, text is mere world salad, everything is just cheap numerology, too many self references, colleagues have not recognized my work, the work has not been published in respected journals, and so on. The additional killer arguments state that I have used certain words which are taboos and already for this reason am a complete crackpot. Examples of bad words are "water memory", "homeopathy", "cold fusion", "crop circles", "quantum biology", "quantum consciousness". There is of course no mention about the fact that I have always emphasized that I am skeptic, not a believer or disbeliever, and only make the question "What if...." and try to answer it in TGD framework. Intellectual honesty does not belong to the virtues of skeptics who are for modern science what jesuits were for the catholic church. Indeed, as Loyola said: the purpose sanctifies the deeds.

Lubos Motl has real arguments but they suffer from the strong negative emotional background coloring so that one cannot be trust the rationality of the reasoning. The core of the arguments of Lubos Motl is following.

1. The water inside reactor is heated to a temperature of 100.1 C. This is slightly above 100 C defining the nominal value of the boiling point temperature at normal pressure. The problem is that if the pressure is somewhat higher, the boiling point increases and the it could happen that the no evaporation of the water takes place. If this is the case, the whole energy fed into the reactor could go to the heating of the water. The input power is indeed somewhat higher than the power needed to heat the water to this temperature without boiling so that this possibility must be taken seriously and the question is whether the water is indeed evaporated.

   Comments:

   (a) This looks really dangerous. Rossi uses water only as a passive agent gathering the energy assumed to be produced in the fusion of hydrogen and nickel to copper. This would allow to assume that the water fed in is at lower temperature and also the water at outlet is below boiling boiling. Just by measuring the temperature at the outlet one can check whether the outgoing water has temperature higher than it would be if all input energy goes to its heating.

   (b) This is only one particular demonstration and it might be that there are other demonstrations in which the situation is this. As a matter fact, from an excellent video interview of Nobelist Brian Josephson one learns that there are also demonstrations in which water is only heated so that the argument of Lubos Motl does not bite here. The gadget of Rossi is already used to heat university building. The reason why the evaporation is probably that this provides an effective manner to collect the produced energy. Also by reading the Nyteknik report [C18] one learns that the energy production is directly measured rather than being based on the assumption that evaporation occurs.

2. Is the water evaporated or not? This is the question posed by Lubos Motl. The demonstration shows explicitly that there is a flow of vapor from the outlet. As Rossi explains there is some

condensation. Lubos Motl claims that the the flow of about 2 liters of vapor per second resulting from the evaporation 2 ml of water per second should produce much more dramatic visual effect. More vapor and with a faster flow velocity. Lubos Motl claims that water just drops from the tube and part of it spontaneously evaporates. This is what Lubos Motl wants to see and I have no doubt that he is seeing it. Strong belief can move mountains! Or at least can make possible the impression that they are moving!

Comments:

(a) I do not see what Lubos Motl sees but I am not able to tell how many liters of vapor per second comes out. Therefore the visual demonstration as such is not enough.

(b) I wonder why Rossi has not added flow meter measuring the amount of vapor going through the tube. Second possibility is to allow the vapor condense back to water in the tube by using heat exchanger. This would allow to calculate the energy gain without making the assumption that all that comes out is vapor. It might be that in some experiments this is done.

3. But why would Rossi use this kind of questionable arrangement susceptible to accusations about fraud? Why not use lower temperature in which evaporation does not take place (Josephson reports that this has been done in some demonstrations)? The presence of dark matter phase is essential in TGD based model for cold fusion by proton absorption, and TGD vision about the generation of dark matter allows to image a possible good reason for working near thermodynamical criticality.

   The phases with large value of Planck constant are associated with quantum criticality involving long range quantum fluctuations, and large scale quantum coherence is assignable to a large value of h_{eff}. To generate dark matter one must create quantum criticality. If thermodynamical criticality is accompanied by quantum criticality at the deeper level, cold fusion would be most effective near thermodynamical criticality. In the similar manner, the doping ratio of Palladium by deuterium in $p + D$ cold fusion must be critical.

   A possible concrete model relies on the generation of large h_{eff} variants of weak bosons effectively massless below the dark weak scale, which relates to the weak scale by a factor h_{eff}/h or $(h_{eff}/h)^{1/2}$ (depending on whether the p-adic length scale is proportional to h_{eff} as suggested by the definition of Compton length or to $(h_{eff}/h)^{1/2}$ as suggested by p-adic mass calculations). In any case case, the weak scale would be scaled down from about 10^{-17} meters to atomic length scale 10^{-10} meters. This would make weak interactions as strong as em interaction below dark weak scale and proton could exchange dark W boson with target nucleus transforming therefore to neutron experiencing no Coulomb wall. Dark weak boson would be absorbed by color bond between nuclei of nuclear string [K15].

To sum up, Lubos Motl in his eagerness to debunk forgets that he is concentrating on single demonstration and forgetting other demonstrations altogether and also the published report [C18] to which his argument do not apply. I remain however skeptic (I mean real skeptic, the skepticism of Lubos Motl and -sad to say- of quite too many skeptics- has nothing to do with a real skeptic attitude). Rossi should give information about the details of his invention and quantitative tests really measuring the heat produced should be carried out and published. Presumably the financial aspects related to the invention explain the secrecy in a situation in which patenting is difficult.

5.2.2 Objections from nuclear physics

The reading of Rossi's paper and Wikipedia article led me to consider in more detail also various nuclear physics based objections against Rossi's reactor [C7]. Coulomb barrier, the lack of gamma rays, the lack of explanation for the origin of the extra energy, the lack of the expected radioactivity after fusing a proton with ^{58}Ni (production of neutrino and positron in beta decay of ^{59}Cu), the unexplained occurrence of 11 per cent iron in the spent fuel, the 10 per cent copper in the spent fuel strangely having the same isotopic ratios as natural copper, and the lack of any unstable copper isotopes in the spent fuel as if the reactor only produced stable isotopes.

1. *Could natural isotope ratios be determined by cold fusion?*

The presence of Cu in natural isotope ratios and the absence of unstable copper isotopes of course raise the question whether the copper is just added there. Also the presence of iron is strange. Could one have an alternative explanation for these strange co-incidences?

1. Whether unstable isotopes of Cu are present or not, depends on how fast ^{A}Cu, $A < 63$ decays by neutron emission: this decay is expected to be fast since it proceeds by strong interactions. I do not know enough about the detailed decay rates to be able to say anything about this.

2. Why the isotope ratios would be the same as for naturally occurring copper isotopes? The simplest explanation would be that the fusion cascades of two stable Ni isotopes determine the ratio of naturally occurring Cu isotopes so that cold fusion would be responsible for their production. As a matter fact, TGD based model combined with what is claimed about bio-fusion led to the proposal that stable isotopes are produced in interstellar space by cold fusion and that this process might even dominate over the production in stellar interiors. This wold solve among other things also the well-known Lithium problem. The implications of the ability to produce technologically important elements artificially at low temperatures are obvious.

   If the reaction rate does not depend on isotope of Ni, the ratio ^{63}Cu/ ^{65}Cu= 69.1/30.9=2.23 should be equal to ^{62}Ni/^{64}Ni= 3.66/1.16=3.15. This is not the case if the isotope ratios are natural.

3. The presence of only stable isotopes is a further serious objection. Why the unstable isotopes would not be created in the process. Ni has several stable isotopes with mass numbers 58, 60, 61, 62, 64 with abundances 67.8, 26.23, 1.25, 3.66, 1.16 per cent. The stable isotopes of Cu have mass numbers 63,65. Isotopes with mass number 59, 61, 62, 63(stable), 65 (stable) should be created. ^{59}Cu is very shortlived. ^{61}Cu and ^{62}Cu have half-lifes of 3.33 h and 9.80 min. Their absence could be understood if the isotope ratios are determined after long enough time, say next day.

2. Could standard nuclear physics view about cold fusion allow to overcome the objections?

Consider now whether one could answer the objections in standard nuclear physics framework as a model for cold fusion processes.

1. By inspecting stable nuclides one learns that there are two fusion cascades. In the first cascade the isotopes of copper would be produced in a cascade starting from with $^{58}Ni + n \rightarrow^{59} Cu$ and stopping at ^{63}Cu. All isotopes ^ACu, $A \in \{55, 62\}$ are unstable with lifetime shorter than one day. The second fusion cascade begins from ^{63}Ni and stops at ^{65}Cu.

2. The first cascade involves five cold fusions and 4 weak decays of Cu. Second cascade involves two cold fusions and one weak decay of Cu. The time taken by the cascade would be same if there is single slow step involved having same duration. The only candidates for the slow step would be the fusion of the stable Ni isotope with the neutron or the fusion producing the stable Cu isotope. If the fusion time is long and same irrespective of the neutron number of the stable isotope, one could understand the result. Of course, this kind of co-incidence does not look plausible.

3. ^{A-5}Fe could be produced via alpha decay $^ACu \rightarrow^{A-4} Co+\alpha$ followed by $^{A-4}Co \rightarrow^{A-5} Fe+p$.

3. Could TGD view about cold fusion allow to overcome the objections?

The claimed absence of positrons from beta decays and the absence of gamma rays are strong objections against the assumption that standard nuclear physics is enough. In TGD framework it is possible to ask whether the postulated fusion cascades really occur and whether instead of it weak interactions in dark phase of nuclear matter with range of order atomic length scale are responsible for the process because weak bosons would be effectively massless below atomic length scale. For TGD inspired model of cold fusion see `tgdtheory.fi/public_html/pdfpool/padnucl.pdf` and `tgdtheory.fi/public_html/padphys/padphys.html#nuclstring` [K21, K15].

1. The nuclear string model assumes that nucleons for nuclear strings with nucleons connected with color bonds having quark and antiquark at their ends. Color bonds could be also charged and this predicts new kind of internal structure for nuclei. Suppose that the space-time sheets mediating weak interactions between the color bonds and nucleons correspond to so large value of Planck constant that weak interaction length scale is scaled up to atomic length scale. The generalization of this hypothesis combined with the p-adic length scale hypothesis is actually standard piece of TGD inspired quantum biology (`tgdtheory.fi/public_html/padphys/padphys.html#darkforces`) [K7].

2. The energy scale of the excitations of color bond excitations of the exotic nuclei would be measured in keVs. One could even consider the possibility that the energy liberated in cold fusion would correspond to this energy scale. In particular, the photons emitted would be in keV range corresponding to wavelength of order atomic length sale rather than in MeV range. This would resolve gamma ray objection.

3. Could the fusion process $^{58}Ni + n$ actually lead to a generation of Ni nucleus ^{59}Ni with one additional positively charged color bond? Could the fusion cascade only generate exotic Ni nuclei with charged color bonds, which would transform to stable Cu by internal dark W boson exchange transferring the positive charge of color bond to neutron and thus transforming it to neutron? This would not produce any positrons. This cascade might dominate over the one suggested by standard nuclear physics since the rates for beta decays could be much slower than the rate for direct generation of Ni isotopes with positively charged color bonds.

4. In this case also the direct alpha decay of Ni with charged color bond to Fe with charged color bond decaying to ordinary Fe by positron emission can be imagined besides the proposed mechanism producing Fe.

5. If one assumes that this process is responsible for producing the natural isotope ratios, one could overcome the basic objections against Rossi's reactor.

The presence of em radiation in keV range would be a testable basic signature of the new nuclear physics as also effects of X-ray irradiation on measured nuclear decay and reaction rates due to the fact that color bonds are excited. As a matter fact, it is known that X-ray bursts from Sun in keV range has effects on the measured nuclear decay rates and I have proposed that the proposed exotic nuclear physics in keV range is responsible for the effect. Quite generally, the excitations of color bonds would couple nuclear physics with atomic physics and I have proposed that the anomalies of water could involve classical Z^0 force in atomic length scales. Also the low compressibility of condensed matter phase could involve classical Z^0 force. The possible connections with sono-luminescence and claimed sonofusion are also obvious (`http://tgdtheory.fi/public_html/padphys/padphys.html#exonuclear`) [K8].

5.2.3 More recent results concerning heat production in Rossi's reactor

According to the article "Indication of anomalous heat energy production in a reactor device containing hydrogen loaded nickel powder" [H2] (`http://arxiv.org/pdf/1305.3913.pdf`) cold fusion has been demonstrated quite convincingly so that "indication" in the title can be take as a humorous understatement.

The studied system is the E-Cat HT of Rossi containing Ni power plus unknown catalyst under hydrogen pressure. The durations of test runs were about 100 hours. Heat cameras were used to measure the temperature at the upper surface of the cylinder. The lower bound for the heat power estimated theoretically from the temperature distribution using estimates for radiation power, very small conduction power through the contacts with environment, and from estimate convection power through the surrounding air. In one of the runs the input power was 360 W and output power 2034 W giving $COP \simeq 5.6$. The run took 96 hours and the weight of Ni cylinder was.236 kg. On basis of this the heat energy per weight is higher than.68 MJ/kg which is higher than for any conventional energy source. This is a lower bound since only the heat energy produced during the test run is included.

To my opinion, it seems safe to conclude that low energy nuclear reactions can be regarded as an established fact and the commercialization is indeed in full swing. It is a pity that at the same

time academic theoretical physics after the results from LHC has reached dead end basically due to the sticking to the reductionistic dogma, which does not allow any new physics above elementary particle length scale - and if we believe string theorists- above Planck length length scale.

5.3 Sono-Luminescence, Classical Z^0 Force, And Hydrodynamic Hierarchy Of P-Adic Length Scales

Sono-luminescence [D6], [D6] is a peculiar phenomenon, which might provide an application for the hydrodynamical hierarchy. The radiation pressure of a resonant sound field in a liquid can trap a small gas bubble at a velocity node. At a sufficiently high sound intensity the pulsations of the bubble are large enough to prevent its contents from dissolving in the surrounding liquid. For an air bubble in water, a still further increase in intensity causes the phenomenon of sono-luminescence above certain threshold for the sound intensity. What happens is that the minimum and maximum radii of the bubble decrease at the threshold and picosecond flash of broad band light extending well into ultraviolet is emitted. Rather remarkably, the emitted frequencies are emitted simultaneously during very short time shorter than 50 picoseconds, which suggests that the mechanism involves formation of coherent states of photons. The transition is very sensitive to external parameters such as temperature and sound field amplitude.

A plausible explanation for the sono-luminescence is in terms of the heating caused by shock waves launched from the boundary of the adiabatically contracting bubble [D6], [D6] . The temperature jump across a strong shock is proportional to the square of Mach number and increases with decreasing bubble radius. After the reflection from the minimum radius $R_s(min)$ the outgoing shock moves into the gas previously heated by the incoming shock and the increase of the temperature after focusing is approximately given by $T/T_0 = M^4$, where M is Mach number at focusing and $T_0 \sim 300\ K$ is the temperature of the ambient liquid. The observed spectrum of sono-luminescence is explained as a brehmstrahlung radiation emitted by plasma at minimum temperature $T \sim 10^5\ K$. There is a fascinating possibility that sono-luminescence relates directly to the classical Z^0 force.

Even standard model reproduces nicely the time development of the bubble and sono-luminescence spectrum and explains sensitivity to the external parameters [D6], [D6]. The problem is to understand how the length scales are generated and explain the jump-wise transition to sono-luminescence and the decrease of the bubble radius at sono-luminescence: ordinary hydrodynamics predicts continuous increase of the bubble radius. The length scales are the ambient radius R_0 (radius of the bubble, when gas is in pressure of 1 atm) and the minimum radius $R_s(min)$ of the shock wave determining the temperature reached in shock wave heating. Zero radius is certainly not reached since shock front is susceptible to instabilities.

5.3.1 p-Adic length scale hypothesis and the length scales of sono-luminescence

Since p-adic length scale hypothesis introduces a hierarchy of hydrodynamics with each hydrodynamics characterized by a p-adic cutoff length scale there are good hopes of achieving a better understanding of these length scales in TGD. The change in bubble size in turn could be understood as a change in the "primary" condensation level of the bubble.

1. The bubble of air is characterized by its primary condensation level k. The minimum size of the bubble at level k must be larger than the electron Compton scale $L_e(k) = \sqrt{5}L(k)$. This suggests that the transition to photo-luminescence corresponds to the change in the primary condensation level of the air bubble. In the absence of photo-luminescence the level can be assumed to be $k = 163$ with $L_e(163) \sim .76\ \mu m$ in accordance with the fact that the minimum bubble radius is above $L_e(163)$. After the transition the primary condensation level of the air bubble one would have $k = 157$ with $L_e(157) \sim .07\ \mu m$. In the transition the minimum radius of the bubble decreases below $L_e(163)$ but should not decrease below $L_e(157)$: this hypothesis is consistent with the experimental data [D6], [D6].

2. The particles of hydrodynamics at level k have minimum size $L(k_{prev})$. For $k = 163$ one has $k_{prev} = 157$ and for $k = 157$ $k_{prev} = 151$ with $L_e(151) \sim 11.8\ nm$. It is natural to assume that the minimum size of the particle at level k gives also the minimum radius for the spherical shock wave since hydrodynamic approximation fails below this length scale. This

means that the minimum radius of the shock wave decreases from $R_s(min, 163) = L_e(157)$ to $R_s(min, 157) = L_e(151)$ in the transition to sono-luminescence. The resulting minimum radius is 11 nm and much smaller than the radius .1 μ m needed to explain the observed radiation if it is emitted by plasma.

A quantitative estimate goes along lines described in [D6], [D6].

1. The radius of the spherical shock is given by

$$R_s = At^\alpha \ , \tag{5.1}$$

where t is the time to the moment of focusing and α depends on the equation of state (for water one has $\alpha \sim .7$).

2. The collapse rate of the adiabatically compressing bubble obeys

$$\frac{dR}{dt} = c_0(\frac{2}{3\gamma}\frac{\rho_0}{\rho}(\frac{R_m}{R_0})^3)^{1/2} \ , \tag{5.2}$$

where c_0 is the sound velocity in gas, γ is the heat capacity ratio and ρ_0/ρ is the ratio of densities of the ambient gas and the liquid.

3. Assuming that the shock is moving with velocity c_0 of sound in gas, when the radius of the bubble is equal to the ambient radius R_0 one obtains from previous equations for the Mach number M and for the radius of the shock wave

$$\begin{aligned} M &= \frac{\frac{dR_s}{dt}}{c_0} = (t_0/t)^{\alpha-1} \ , \\ R_s &= R_0(t/t_0)^\alpha \ , \\ t_0 &= \frac{\alpha R_0}{c_0} \ . \end{aligned} \tag{5.3}$$

where t_0 is the time that elapses between the moment, when the bubble radius is R_0 and the instant, when the shock would focus to zero radius in the ideal case. For $R_0 = L_e(167)$ (order of magnitude is this) and for $R_s(min) = L_e(151)$ one obtains $R_0/R_s(min) = 256$ and $M \simeq 10.8$ at the minimum shock radius.

4. The increase of the temperature immediately after the focusing is approximately given by

$$\frac{T}{T_0} \simeq M^4 = (\frac{R_0}{R_s})^{\frac{4(1-\alpha)}{\alpha}} \simeq 1.3 \cdot 10^4 \ . \tag{5.4}$$

For $T_0 = 300$ K this gives $T \simeq 4 \cdot 10^6$ K: the temperature is far below the temperature needed for fusion.

In principle the further increase of the temperature can lead to further transitions. The next transition would correspond to the transition $k = 157 \to k = 151$ with the minimum size of particle changing as $L_e(k_{prev}) \to L_e(149)$. The next transition corresponds to the transition to $k = 149$ and $L_e(k_{prev}) \to L_e(141)$. The values of the temperatures reached depend on the ratio of the ambient size R_0 of the bubble and the minimum radius of the shock wave. The fact that R_0 is expected to be of the order of $L_e(k_{next})$ suggests that the temperatures achieved are not sufficiently high for nuclear fusion to take place.

5.3.2 Could sonoluminescence involve the formation of a phase near vacuum extremals?

In TGD inspired model of cell membrane [K19] a key role is played by almost vacuum extremals for which the induced Kähler field is very small. Vacuum extremals are accompanied by a strong classical Z^0 field proportional to classical electromagnetic field and given by $Z^0 = -2\gamma/p$, $p = sin^2(\theta_W)$. One could also imagine that em field is vanishing in which case Z^0 field is proportional to Kähler field and also strong because of $Z^0 = 6J/p$, $p = sin^2(\theta_W)$ proportionality. In this case also classical color fields are present. It is however not clear whether these fields can be realized as preferred extremals of Kähler action.

The classical Z^0 field should have a source and the vacuum polarization in the sense that flux tubes are generated with many fermion state and its conjugate at its opposite ends would generate it. The Compton scale of weak bosons must correspond to $L_e(157)$ so that either dark variants of ordinary weak bosons or their light variants would be in question. Both would be effectively massless below $L_e(157)$. The simplest situation corresponds to many-neutrino state for vacuum extremals but also many quark states are possible when em field for the flux tube vanishes.

The length scales involved correspond to Gaussian Mersennes $M_{G,k} = (1+i)^k - 1$ and together with $k = 151$ and $k = 167$ define biologically important length scales [K19]. The p-adically scaled up variants and dark variants of of QCD and weak physics have been conjectured to play key role in biology between length scales 10 nm (cell membrane thickness) and 2.5 μm (the size scale of nucleus). This motivates the question whether a nearly vacuum extremal phase (as far as induced gauge fields are considered) accompanies the transition changing the p-adic length scale associated with the bubble from $k = 163$ to $k = 157$. The acceleration in the strong Z^0 field associated with the flux tubes could generate the visible light as brehmstrahlung radiation, perhaps also Z^0 and W bremstrahlung could be generated and would decay to photons and charged particles and generate a plasma in this manner. If the weak scale is given by $k_W = 157$, the mass scale of weak bosons is $2^{-31} \simeq 10^{-9}/2$ times smaller than that of ordinary weak bosons (about 50 eV which corresponds to a temperature of 5×10^5 K). A further transition to $k = 151$ would correspond to gauge boson mass scale 400 eV and temperature or order 4×10^6 K.

5.3.3 Could phase transitions increasing Planck constant and p-adic prime accompany sono-luminescence

In sonoluminescence external sound source induces oscillation of the radius of a bubble of water containing noble gas atoms. The unexpected observation is generation of radiation even at gamma ray energies and it is proposed that nuclear fusion might take place.

A possible new element in the model is h_{eff} increasing phase transition of the space-time sheet containing the water vapour and other atoms to dark phase during the expansion phase and reduction back to the ordinary value during implosion period now forced by the sound wave. If implosion actually takes place spontaneously then the energy of sound wave could be liberated as luminescence. If also dark hydrogen atoms are generated, dark protons could be able to circumvent the Coulomb wall so that low energy nuclear reactions could occur. On the other hand, if the phase transition reducing the Planck constant and increasing p-adic length scale takes place for the water space-time sheet in such a manner that the two scale changes compensate each other (this requires $h_{eff} = 2^k h$ and $p \to 2^{2k} p$ (this in excellent approximation), zero point kinetic energy (ZPKE) is liberated and could heat the bubble and induce high energy radiation and perhaps even the proposed ordinary fusion. Cold fusion however seems more elegant alternative. The fact that neutron yield has not been observed in sonoluminescence suggests that ordinary hot fusion is not involved.

I have earlier considered the possibility that classical long ranged Z^0 fields predicted by TGD might be involved and give rise to a new interaction possibly related to sonoluminescence. I have proposed that classical Z^0 fields could play a role in the physics of cell membrane. The speculative proposal is that cell membrane could be in two possible states: the first ("ordinary") state would correspond to far from vacuum extremal for which electric field dominates. Second state would be near to vacuum extremal: in this case classical Z^0 field would dominate and give rise to rather radical modification of the model for cell membrane since Z^0 membrane potential would replace the ordinary one. Neurons serving as sensory receptors might correspond to this phase.

This model remains very speculative as also the possible role of classical Z^0 fields in sonofusion. Note however that the phase transition increasing h_{eff} implies a dilution to vapour like phase ("electrically expanded water")and means that the state is near vacuum. By quantum classical correspondence classical Z^0 fields might become important. In the case of cell membrane Z^0 Coulomb energy defined by Z^0 potential is much stronger than its electronic counterpart and corresponds to voltage of order few eV and therefore to visible photon energies roughly 50 times higher than the energies assignable to the ordinary membrane potential of about.06 eV. One can wonder whether similar effect could appear also in electrolysis where also strong local electric fields appear.

6 The TGD Variant Of The Model Of Widom And Larsen For Cold Fusion

Widom and Larsen (for articles see the Widom Larsen LENR Theory Portal [C5] (`http://newenergytimes.com/v2/sr/WL/WLTheory.shtml`)) have proposed a theory of cold fusion (LENR) [C3], which claims to predict correctly the various isotope ratios observed in cold fusion and accompanying nuclear transmutations. The ability to predict correctly the isotope ratios suggests that the model is on the right track. A further finding is that the predicted isotope ratios correspond to those appearing in Nature which suggests that LENR is perhaps more important than hot fusion in solar interior as far as nuclear abundances are considered. TGD leads to the same proposal and Lithium anomaly could be understood as one implication of LENR [K15]. The basic step of the reaction would rely on weak interactions: the proton of hydrogen atom would transform to neutron by capturing the electron and therefore would overcome the Coulomb barrier.

6.1 Challenges Of The Model

The model has to meet several challenges.

1. The electron capture reaction $p + e \to n + \nu$ is not possible for ordinary atom since the mass difference of neutron is 1.3 MeV and larger than electron mass.5 MeV (electron has too small kinetic energy). The proposal is that strong electric fields at the catalyst surface imply renormalization effects for the plasmon phase at the surface of the catalyst increasing electron mass so that it has width of few MeVs [C27]. Physically this would mean that strong em radiation helps to overcome the kinematical threshold for the reaction. This assumption [C19]: the claim is that the mass renormalization is much smaller than claimed by Widom and Larsen.

2. Second problem is that weak interactions are indeed very weak. The rate is proportional to $1/m_W^4$, $m_W \sim 100$ GeV whereas for the exchange of photon with energy E it would be proportional to $1/E^4$. For $E \sim 1$ keV the ratio of the rates would be of the order of 10^{-48}!

   This problem could be circumvented if the transition from proton to neutron occurs coherently for large enough surface patch. This would give rate proportional to N^2, where N is the number electrons involved. Another mechanism hoped to help to get high enough reaction rate is based on the assumption that the neutron created by the capture process has ultra-low momentum. This is the case if the mass renormalization of electron is such that the energies of the neutrons produced in the reaction are just above the kinematical threshold. Note however that this reduces the electron capture cross section. The argument is that the absorption rate for neutron by target nucleus is by very general arguments proportional to $1/v_n$, v_n the velocity of neutron. Together these two mechanisms are hoped to give high enough rate for cold fusion.

3. The model must also explain why gamma radiation is not observed and why neutrons are produced much less than expected. Concerning gamma rays one must assume that the heavy electrons of the plasmon phase assigned to the surface of the catalyst absorb the gamma rays and re-emit them as infrared light emitted to environment as heat. Ordinary electrons cannot absorb gamma rays but heavy electrons can [C26], and the claim is that they do

transform gamma rays to infrared photons. If the neutrons created in LENR have ultra-low energies their capture cross sections are enormous and the claim is that they do not get out of the system.

The assumption that electron mass is renormalized so that the capture reaction can occur but occurs only very near threshold so that the resulting neutrons are ultraslow has been criticized [C19].

6.2 TGD Variant Of The Model

TGD allows to consider two basic approaches to the LENR.

1. **Option I** involves only dark nucleons and dark quarks. In this case, one can imagine that the large Compton length of dark proton - at least of order atomic scale - implies that it overlaps target nucleus, which can see the negatively charged d quark of the proton so that instead of Coulomb wall one has Coulomb well.

2. **Option II** involves involves both dark weak bosons and possibly also dark nucleons and dark electrons. The TGD inspired model for living matter - in particular, the model for cell membrane involving also Z^0 membrane potential in the case of sensory receptor neurons [K7] - favors the model involving both dark weak bosons, nucleons, and even electrons. Chiral selection for biomolecules is extremely difficult to understand in standard model but could be understood in terms of weak length scale of order atomic length scale at least: below this scale dark weak bosons would be effectively massless and weak interactions would be as strong as em interactions. The model for electrolysis based on plasmoids identified as primitive life forms supports also this option. The presence of dark electrons is suggested by Tesla's cold currents and by the model of cell membrane.

   This option is fixed quantitatively by the condition that the Compton length of dark weak bosons is of the order of atomic size scale at least. The ratio of the corresponding p-adic size scales is of order 10^7 and therefore one has $h_{eff} \sim 10^{14}$. The condition that $h_{eff}/h = 2^k$ guarantees that the phase transition reducing h_{eff} to h and increasing p-adic prime p by about 2^k and p-adic length scale by $2^{k/2}$ does not change the size scale of the space-time sheet and liberates cyclotron magnetic energy $E_n(1 - 2^{-k}) \simeq E_n$.

Consider next **Option II** by requiring that the Coulomb wall is overcome via the transformation of proton to neutron. This would guarantee correct isotope ratios for nuclear transmutations. There are two options to consider depending on whether a) the W boson is exchanged between proton nucleus (this option is not possible in standard model) or b) between electron and proton (the model of Widom and Larsen relying on the critical massivation of electron).

1. **Option II.1**. Proton transforms to neutron by exchanging W boson with the target nucleus.

   (a) In this case kinematics poses no obvious constraints on the process. There are two options depending on whether the neutron of the target nucleus or quark in the neutral color bond receives the W boson.

   (b) If electron and proton are dark with $h_{eff}/h = n = 2^k$ in the range $[10^{12}, 10^{14}]$ the situation can change since W boson has its usual mass from the point of view of electron and proton. $\hbar^4/m_W^4$ factor in differential cross section for 2-to-2 scattering by W exchange is scaled up by n^4 (see the appendix of [**?**] so that effectively m_W would be of order 10 keV for ordinary $\hbar$.

   (c) One can argue that in the volume defined by proton Compton length $\lambda_p \simeq 2^{-11}\lambda_e \in [1.2, 12]$ nm one has a superposition of amplitudes for the absorption of dark proton by nucleus. If there are N nuclei in this volume, the rate is proportional to N^2. One can expect at most $N \in [10^3, 10^6]$ target nuclei in this volume. This would give a factor in the range $10^9 - 10^{12}$.

2. **Option II.2**: Electron capture by proton is the Widom-Larsen candidate for the reaction in question. As noticed, this process cannot occur unless one assumes that the mass of electron is renormalized to have a value in a range of few MeV. If dark electrons are heavier than ordinary, the process could be mediated by W boson exchange and if the electron and proton have their normal sizes the process occurs with same rate as em processes.

   If electron and proton are dark with $h_{eff}/h = n \in [10^{12}, 10^{14}]$ the situation can change since W boson has its usual mass from the point of view of electron and proton. 2-to-2 cross section is proportional to $\hbar^4$ and is scaled up by n^4. One the other hand, the naive expectation is that $|\Psi(0)|^2 \propto m_e^3/h_{eff}^3 \propto 1/n^{-3}$ for electron is scaled by n^{-3} so that the rate is increased by a factor of order $n \in [10^{12}, 10^{14}]$ (electron Compton length is of order cell size scale! instead of Angstrom) from its ordinary value. This is not enough.

   On the other hand, one can argue in the volume defined by proton Compton size one has a superposition of amplitudes for the absorption of electron. If there are N dark electrons in this volume, the rate is proportional to N^2. One can expect at most 10^6 dark electrons in the volume of scale 10 nm so that this could give a factor 10^{12}. This would give amplification factor 10^{26} to the weak rate so that it would be only by two orders of magnitude smaller than the rate for massless weak bosons.

There are also other strange features to be understood.

1. The absence of gamma radiation could be due to the fact that the produced gamma rays are dark. For $h_{eff}/h \in [10^{12}, 10^{14}]$ the energy frequency of 1 MeV dark gamma ray would correspond to that of photon with energy of [1, .1] μeV and thus to radio wave photon with wavelength of order 1 m and frequency of order 3×10^8 Hz. In Widom-Larsen model the photons would be infrared photons. The decay of the dark gamma ray to a bunch of ordinary radio wave photons should be observed as radio noise. Note that Gariaev has observed transformation of laser light scattered from DNA to radio wave photons with frequencies down to 1 kHz at least.

2. The absence of the neutrons could be understood if they are dark and simply do not interact with visible matter before phase transition to ordinary neutrons. One can imagine an alternative interpretation allowing the interaction and assuming that nuclei are dark in the reaction volume. The large Compton wavelength implies that dark neutrons are absorbed by dark nuclei coherently in a volume of order 1.2-12 nm so that an additional amplification factor $N^2 \in [10^9, 10^{12}]$ would be obtained. The absorption cross section for neutrons should be proportional to $\hbar^2$ giving a huge amplification factor in the range $[10^{24}, 10^{48}]$. Effectively this corresponds to the assumption of Widom and Larsen stating that neutrons have ultra-low momentum.

The natural question is why h_{eff} us such that the resulting scale as photon wavelength corresponds to energy in scale 10-100 keV. The explanation could relate to the predicted exotic nuclei obtained by replacing some neutral color bonds connecting nucleons with charged ones and exchange of weak boson would affect this replacement. Could the weak physics associated with $h_{eff} \in [10^{12}, 10^{14}]$ be associated with dark color bonds? The reported annual variations of the nuclear reaction rates correlating with the distance of Earth from Sun suggest that these variations are induced by solar X rays [C15].

7 Does ZPE Have TGD Counterpart?

The attempts to understand Brown's gas and related phenomena involve the notion of zero point energy (ZPE). This notion can be criticized as mathematically unacceptable and also physical objections against it can be found. In TGD framework dark matter and dark energy are realized in non-conventional manner. Many-sheeted space-time concept (see **Fig.** `http://tgdtheory.fi/appfigures/manysheeted.jpg` or **Fig.** 9 in the appendix of this book) implies also the notion of zero point kinetic energy (ZPKE) as zero point kinetic energy of a particle localized inside space-time sheet: p-adic length scale hypothesis allows to quantify this notion. These notions

replace the ZPE but do not provide any magic energy source. Even more science fictive option can be imagined: zero energy ontology (ZEO) makes possible effectively the creation of matter from vacuum without breaking conservation laws. In the following I compare ZPE and TGD based approach to make it easier to understand the TGD inspired model for Brown's gas.

7.1 Moddell And ZPE

Garret Moddell has written an excellent popular article about ZPE (`http://ecee.colorado.edu/~moddel/QEL/Papers/VacEnergyExtrac_Jan10.pdf`). Moddell and Haisch have proposed a model for how one might be able to utilize ZPE. Moddell mentions the proposal at the end of the article.

The article represents some basic physical objections against ZPE. The most serious mathematical objection against ZPE is that in QED vacuum energy density assignable to virtual photons and fermion pairs is strictly infinite or zero: depending on whether one performs so called normal ordering which is mathematically acceptable but not elegant. One can perform a cutoff in frequencies at say Planck frequency to get finite vacuum energy. This however breaks Lorentz symmetry.

In supersymmetric theories ZPE vanishes identically. This conforms with the physical view about vacuum energy as energy due to the closing of the system to a finite volume: Uncertainty Principle implies ZPE for all particles including photon. As the size of the volume becomes infinite, ZPE should vanish. One can imagine also forms of vacuum energy for which the density is finite. In particular, energy density of Higgs field for a state with non-vanishing vacuum expectation value can be non-vanishing and finite. Usually ZPE does not however mean this.

The basic physical objections discussed by Moddell are following. Moddell considers objections against two ideas for extracting ZPE and then represents the proposal by him and Haisch.

1. Standard physics argument is that a system able to extract ZPE would be Maxwell demon and thus break second law of thermodynamics. A very plausible sounding objection to this is that one could use diode which allows current only in second direction. Electrons absorb virtual photons of ZPE and are gradually transferred to another electrode so that their energy is transformed to electrostatic energy. In fact any noise can produce this kind of effect and one can indeed realize this situation (see below). Moddell actually leaves open whether this kind of process should happen or not.

   The fact is however that the charging does not happen without some artificial background noise: the straightforward conclusion would be that ZPE vanishes so that the argument pro ZPE turns against ZPE.

   The so called ratchet principle (`http://en.wikipedia.org/wiki/Ratchet_(device)`) is a generalization of the diode idea to any system in which change of dynamical variable can be only in one direction due to the presence of constraints. The ratchet can be also mechanical and is used in machinery. That background noise can be transformed to mechanical work is demonstrated experimentally (`http://www.nld.ds.mpg.de/~bioentropy/material/Toyabe2010.pdf`). The claim of the article that this demonstrates also Maxwell demon at work is to my opinion wrong. This experiment however suggest that if ZPE is there it should in principle make itself visible in diode like systems. It does not.

   Stochastic resonance is a phenomenon analogous to what happens in ratchet: here random noise amplifies oscillations of bistable oscillator (two equilibrium positions) if the oscillation frequency is suitable related to the frequency like parameter characterizing the noise. For instance, brains use stochastic resonance to amplify weak signals.

2. One can ask whether it could be possible to transfer energy from the frequency distribution of the vacuum energy to a frequency range where it can be used. In recent electronics only radio frequencies can be used and the photon energies proportional to frequency are very small. Could it be possible to transform low frequency photons to higher frequency ones, say visible photons. This does not work according to an argument developed by Einstein: induce and spontaneous emissions guarantee that the energy transfers occur in both directions and compensate each other.

In fact, TGD predicts the desired mechanism although the motivations was not this. For large value of Planck constant $h_{eff} = nh$ the energy of dark photon is given by $E = h_{eff}f$ and therefore low frequency photons, say EEG photons with extremely low energy much below physiological thermal threshold, can become very energetic. This makes quantum coherence possible in long length scales. TGD based model of living matter relies on this mechanism. Tesla's cold currents could consist of dark electrons.

3. The third trial is based on Casimir cavities. For Casimir cavities the notion of ZPE is physically well-motivated and experimentally verified as a force between the conductor sheets of the cavity. This does not however provide infinite energy source. The reason is that the force is conservative. If one manages to get continually work from the system one must do the compensating work to return the system to the original state.

4. Moddel and Haisch propose a modification based on ZPE. One brings into the cavity atoms and assumes that they have lower ground state energy than outside the cavity. The atoms go to the lower ground state and radiate energy which can be used. After than the atoms are brought out and they return to the ordinary ground state by extracting ZPE.

   The basic objection is that the ground state energy of atoms is expected to be higher inside the cavity than outside. The zero point energy due to the closure of atomic to the cavity increases its energy and also the zero point energy of virtual photons is inside cavity is expected to be higher than outside by Uncertainty Principle. Therefore one would not gain energy.

   If the energy is indeed lower inside the cavity (for instance, one might argue that this could be due to the phenomenon replacing that principal quantum number n of hydrogen atom by $1/n$ as claimed by Randell Mills). Of course, if ZPE vanishes it requires work to get the atoms out of the cavity.

The proposal of Moddell and Haisch have been tested in the laboratory led by Moddell. Olgar Dimitrieva has made a thesis about the heat production in LENR (cold fusion) believed to take place in cold fusion (`http://ecee.colorado.edu/~moddel/QEL/Papers/DmitriyevaThesis12.pdf`) [C23]. The thesis contains an Appendix which is about the testing of the proposal of Moddell and Haisch and not directly related to the content of the thesis.

The conclusion of the abstract of the Appendix is that conventional models for the thermodynamics of Casimir cavity do not explain the findings completely. Photon emissions in IR range are observed. From the text one however learns that the ZPE predictions for gas in Casimir cavity are not consistent with what was observed.

In more detail the argument goes as follows.

1. Stochastic electrodynamics (not standard QED) is the starting point. ZPE photons are absorbed and emitted and equilibrium situation prevails. Electrons emit Larmor radiation changing the spin direction of electron "down" in absence of absorption of ZPE. In equilibrium the energies should shift: effect would be Lamb+Casimir that is Lamb in finite cavity. The hope is that energies shift downwards. This is not proven. Above just the opposite is argued to happen.

2. The walls of Casimir cavity should be conducting. This is guaranteed by gold coated filter through which gas flows to the cavity and out of it. Several gases have been tested and also non-coated filters for which Casimir effect should be absent.

3. IR emission was observed. Contrary to expectations He gas produces highest emission and it does not matter whether coating is present or not so that Lamb+Casimir does not explain the finding.

The thesis proper demonstrates that anomalous heat production takes place in H-D cold fusion. The hypothesis that certain chemical reaction could explain the heat production is studied. This model is not excluded but it is noticed that it does not work in more general cold fusion: say when D is replaced with Ni.

7.2 To What ZPE Corresponds In TGD Universe?

The comparison of ZPE based explanations of claimed free energy phenomena demonstrates correspondence between ZPE and certain TGD based notions. Dark matter as large h_{eff} phases magnetic bodies whose magnetic energy corresponds to dark energy seems to take the role of ZPE to some extent. A third important piece is p-adic length scale hypothesis and the proposal that zero point kinetic energies (ZPKE as opposed to ZPE) for particles topologically condensed on space-time sheets define a hierarchy of metabolic energy quanta.

Both hydrinos, hydrolysis and strange properties of Brown's gas, cold fusion, Tesla's cold currents, the phenomena related to rotating magnetic systems (Yildiz magnetic motor) have models involving these concepts. Also the characteristic features of living matter are modelled using same notions. Even remote mental interactions would rely on same universal mechanism involved magnetic body and dark matter in TGD sense.

This generality is what encourages to take seriously this approach and the details of particular model are bound to vary as more data emerges.

A further element is zero energy ontology (ZEO), which makes possible to literally create worlds from vacuum meaning apparent breaking of conservation laws.

1. The reason is that quantum states correspond to physical events in ordinary ontology: pairs of positive and negative energy state corresponding to the initial and final state of physical event. The usual positive energy ontology can be seen as an erratic extrapolation assuming much more than observations actually allow to assume. Conservation laws and symmetries are not broken in the re-creation process associated with the quantum jump leading to state function reduction.

2. Conservation laws hold always only in scale defined by the causal diamond (CD) defined as intersection of two light-cones in opposite time directions). Positive and negative energy parts of the states reside at opposite boundaries of given CD and CDs form a fractal scale hierarchy. This is actually anything terribly new. The notion of renormalization group has been part of quantum field theories from the beginning. What is new that one gives up the notion of positive energy state as a fundamental notion.

3. The connection with positive energy ontology is that the observer which is small as compared to the CD in question sees either the positive or negative energy part of the state and therefore uses positive energy ontology (sign of energy is of course convention). If CD is much smaller than observer, observer sees the zero energy states as quantum fluctuation.

There are actually indications for necessity of ZEO already in existing physics.

1. In the model of superconductivity coherent states are essential. Coherent state is quantum superposition with all possible boson numbers. In superconductivity bosons are fermion pairs. Therefore the super-selection rule that the fermion number of quantum state is well-defined is broken and in principle fermion number non-conservation becomes possible. In ZEO this problem disappears.

2. In cosmology energy is not conserved in cosmic scales but is conserved in laboratory scales (Poincare invariance of particle physics). The resolution of the problem is that that the relevant ZEOs have totally different size scales in cosmology and particle physics.

3. The basic prediction of quantum measurement theory based on ZEO is that the direction of thermodynamical arrow of time alternates in the sequence of state function reductions taking place to the two boundaries of given CD. The reason is that the resulting zero energy states have definite and opposite arrow of geometric time reflecting itself also at the space-time geometry and topology by quantum classical correspondence. Fantappie was an Italian theoretical physicist who observed already at thirties that in living matter the arrow of thermodynamical time seems to be variable and introduced the notion of syntropy which could be identified as entropy with non-standard time direction. Also phase conjugate laser rays obey second law in wrong direction of time.

4. In free energy phenomena cooling of environment is often reported suggesting non-standard arrow of geometric time and transformation of heat to work temporarily not allowed by the standard form of second law, which generalizes in ZEO.

I wrote about the relationship of ZEO and ZPE a blog article (`http://matpitka.blogspot.fi/2013/05/about-god-theory-of-bernard-haisch.html`). The basic point is that the idea about creation essential for the "God theory" of Haisch - leads to difficulties with conservation laws. ZPE is the proposed solution. To my opinion it is not since XPE breaks the Lorentz invariance of the theory and forces to make ad hoc assumption about the interaction of matter with ZPE.

Creation (or re-creation) as quantum jump in positive energy ontology would break the laws of physics. In ZEO this is not the case. Quantum jumps replaces quantum superposition of worlds obeying laws of physics with a new one. Conservation laws are not broken.

I have not applied the idea about re-creation to explain any anomalies: just to avoid irritating colleagues too much.

7.2.1 ZPKE as analog of ZPE?

ZPE has also ZPKE (zero point kinetic energy) of particle topological condensed at given space-time sheet as TGD analog.

1. Space-time sheets have finite size. This implies zero point kinetic energy (ZPKE) for all particles. Even for photons in the same way as in wave guide. It is easy to estimate the value of ZPKE if one can assume that kinetic energy dominates and one has non-relativistic situation. For a particle of mass m inside a space-time sheet of size L one has apart from a numerical factor

$$E_0 \propto \frac{\hbar^2\pi^2}{2mL^2} \quad .$$

   E_0 does not depend on h_{eff} replacing h in general case since L scales like h_{eff}.

2. p-Adic length scale hypothesis inspired by p-adic mass calculations replaced L by a a hierarchy of p-adic length scales L_p with p-adic primes satisfying $p \simeq 2^k$ and $p < 2^k$. Especially favored are Mersenne primes $p = M_n = 2^n - 1$ and their complex counterparts. p-Adic length scales can be expressed in excellent approximation in the form $L_p \equiv L(k) = 2^(k - 151)/2) \times L(151)$, $L(151) = 10$ nm, which happens to be the thickness of cell membrane. The numerical factor in E_0 does not depend on p if p-adic fractality is assumed. This makes possible to make rather precise predictions.

3. ZPKE is clearly analogous to Casimir effect. Now the cavity containing photons is replaced with space-time sheet and virtual photons inside cavity are replaced with real particles. In fact, the analog of Casimir effect is expected since the total energy of particle system depends on the size of the space-time sheet.

It turns out that for proton the ZEPK for condensation at $k = 137$ space-time sheet equals (note that $k = 137$ is inverse of fine structure constant) is about.5 eV and corresponds to the nominal value of metabolic energy quantum. The ZPKE is same for electron condensed at $k = 149$ space-time sheet since the masses of electron and proton relate approximately by a factor 2^{-11}. $L(149)$ corresponds to the thickness of the lipid layer of cell membrane. The proposal is that metabolic energy quanta (at least those above thermal energy) form a fractal hierarchy.

One can imagine two mechanisms by which zero point kinetic energies can serve as metabolic energy quanta.

1. Option I (the original proposal). Particles at given space-time sheet can drop to a larger space-time sheet leading to a liberation of ZPKE. The dropping of $k = 137$ proton or $k = 149$ electron to a larger space-time sheet would lead to a liberation of a metabolic energy quantum. On the other hand, if particles are driven to smaller space-time sheet they gain zero point kinetic energy.

2. Option II (the new one). Phase transitions changing the p-adic prime of the space-time sheets containing the particles are possible. Dropping is therefore not necessary! These phase transitions can increase the value of p-adic prime and reduce ZPKE leading to a liberation of ZPKE as usable energy. This system indeed serves as the analog of population reversed laser since all particles experience the reduction of ZPKE simultaneously, and can liberate large amounts of energy in a quantum coherent phase transition like manner.

7.3 Hierarchy Of Planck Constants

7.3.1 Background

1. The observations about effects of radiation at ELF frequencies on vertebrate brain was the first motivation for the hierarchy of Planck constant identified in terms of phases of matter behaving like dark matter locally. What was found were quantal effects assignable to cyclotron transitions in magnetic field of magnitude $B = .2$ Gauss which is 2/5 of the Earth's magnetic field and identified as endogenous magnetic field. Cyclotron energies in field of this strength are how extremely and quantum effects should be totally masked by the thermal noise. The attempts to understand why EEG manages to correlate so strongly with the state of brain and what is the function of EEG meet the same problem. If $h_{eff} = nh$ is assumed the situation changes and $E = h_{eff}f$ allows to have photon energies above thermal threshold even for ELF frequencies if h_{eff} is large enough. It is known that dark matter accounts most of the matter and also that dark energy is also present. The natural hypothesis is that dark matter corresponds to large $h_{eff} = nh$ phases at magnetic flux quanta and dark energy to the magnetic energy of the flux quanta carrying magnetic monopole fluxes.

2. The observation that the stoichiometry of water is $H_{1.5}O$ in atto second time scales (in ZEO this statement makes sense) led to the conclusion that every fourth proton is dark in the sense that it is not visible in neutron diffraction and electron scattering. The presence of dark protons and even dark nuclei formed as string like structures formed by them and possibly forming analogs of atoms involving also dark electrons, could relate to the thermodynamical anomalies of water.

7.3.2 A possible model for dark particles

The proposed model involving only phase transitions for the space-time sheet at which particles of water are topologically condensed, is certainly the simplest one but not the only possible option for darkness. For instance, one can consider dark variants of proton and electron and in the model of living matter they play a key role.

1. A model for dark electrons (`http://tgdtheory.fi/public_html/articles/teslaling.pdf`, [K27]) assignable to neuronal cell membrane combines increase of effective Planck constant and increase of p-adic prime characterizing the partcle and the idea about fractionized particle as n-particle state of 1/n-fractionized particles with quantum numbers scaled down by $1/n$-factor. These states are obtained by a phase transition increasing $h_{eff} = nh$, $n = 2^k$. This induces fractionization of the particle to n-sheeted structure. p-adic length assignable to the n space-time sheets of the dark particle is scaled to p-adic prime $\simeq 2^k p$ so that mass at given sheet is scaled down by $1/n$ factor for each fractional particle at each sheet. Since there are n sheets mass remains unchanged. Same applies to all quantum numbers.

2. One can consider several variants of dark proton. The space-time sheet associated with proton with size scale of proton Compton length can become dark but quarks remain as such. One would have $n = 2^k$ 1/n-fractional protons at n sheets of the covering with total quantum numbers same as for ordinary proton and p-adic length scale scaled up by a factor 2^k. Also the quarks inside proton can become dark and their size therefore can increase. This could give rise to the proposed dark protons possibly explaining the strange stoichiometry of water at atto-second time scale and also various anomalies of water.

7.3.3 Applications in biology

Magnetic body whose flux quanta carry dark particles as cyclotron Bose-Einstein condensates is basic element of TGD inspired view about living matter [K27]. The "motor actions" of the magnetic body have key role in the model.

1. Inside cell phase transitions increasing or reducing the volume of cytoplasm are general ("electric expansions" and implosions in Brown's gas). The proposal is that these phase transitions are induced by h_{eff} changing phase transitions for magnetic flux tubes inducing the corresponding change of their length. The same mechanism could also bring together distant molecules connected by flux tubes in very selective manner: this would make possible for molecules to find each other in the molecular crowd of cytoplasm.

2. Reconnection of flux tubes in turn makes it possible to build flux tube connections with other molecules by controlling the thickness of the flux tube and therefore the value of the local magnetic field, which must be same for two reconnecting flux tubes. This implies also that cyclotron frequencies are same. This makes possible a mechanism of directed attention and sense of presence at molecular level since molecule can generate negentropic entanglement with another one by this mechanism. In fact, the the basic task of ATP would be to build reconnections between molecules and build at the same time negentropic entanglement. Metabolic energy as such would not be fundamental: conscious experience made possible by the negentropic entanglement (see **Fig.** `http://tgdtheory.fi/appfigures/cat.jpg` or **Fig. ??** in the appendix of this book) would be more fundamental. Later a more precise view about what happens when metabolic energy is used will be considered.

3. An observation which came as a complete surprise was that in a simple model for dark proton the states can be classified in such a manner that they correspond to DNA, RNA, tRNA and amino-acids. Also vertebrate genetic code had natural realization as mapping between DNA type states and amino-acid type states [K13]. This generated the idea that genetic code and counterparts of fundamental biomolecules are realized already at the level of dark nuclear physics. This would of course revolutionize the views about biology. What we seen in biochemistry would be only shadows on the wall of Plato's cave. Dark biomolecules would also make possible R&D at the level of biology since dark biology would make possible kind of virtual biology: experimentation is done first using dark biomolecules and if something working is found, transcription to ordinary biomolecules is carried out. Water memory, homeopathy, basic mechanism of immune system, and cell membrane containing copy of DNA as dark DNA realized as dark proton sequences are ensuing proposals [K13]. Water would be living: genetic code for water clusters would be realized as sequences of dark protons.

7.4 How P-Adic Length Scale Hypothesis And Hierarchy Of Planck Constants Are Related?

p-Adic length scale hypothesis and the hypothesis about hierarchy of metabolic energy quanta are corner stones of TGD inspired view about living matter. Also the hierarchy of Planck constants plays a crucial role and one expects a connection between the two notions. I have not been able to integrate these ideas together in a really convincing manner.

The attempt to achieve this integration in the general model for free energy anomalies however led to a small modification of the existing view about how zero point kinetic energy could be liberated as metabolic energy quanta could allow to fuse this notion with that of hierarchy of Planck constants: the scaling of h to nh_{eff} for $n = 2^k$ for space-time sheet containing particle followed by the reverse scaling and p-adic phase transition increasing p by factor $n = 2^k$ (in excellent approximation would reduce ZPKE and therefore liberate zero point kinetic energy as usable energy.

8 TGD Inspired Model Of Brown's Gas And Related Phenomena

Many claimed free energy phenomena relate to the electrolysis of water (hydrolysis) induced by various manners (usually by a current running between electrodes) with two water molecules producing $2H_2$ and O_2. If water splitting involves only standard chemistry, it would require energy. Experimenters however report that the reaction liberates energy. Electrolysis without power feed is the ultimate test for the concept and closed loop electrolysis has been reported by two groups of Steven Eaton and Jeff Sokol and Oliver and Valentin mentioned in the lectures of Moray B. King [H3] (`http://www.sciencedirect.com/science/article/pii/S1875389211006079`). The notion of hydrino atom as scaled down hydrogen atom with fractionization of the principal quantum number n (Mills suggests $n \to 1/n$ [D8] but also $n \to n/m$, $m = 2, 3, ...$ can be considered) is related also to hydrolysis.

Also cold fusion for which evidence is growing involves electrolysis. Coulomb wall makes cold fusion impossible in standard physics framework so that academic community as a rule refuses to take the cold fusion claims seriously. There might be a connection between the energy production in hydrolysis and cold fusion: for instance, Kanarev, who has studied hydrolysis and cold fusion expert Mizuno have indeed reported the occurrence of cold fusion in hydrolysis.

The general strategy concerning the understanding of free energy relies on the assumption that a very large class of anomalous phenomena rely on same basic mechanism. This includes life as a phenomenon, water memory and homeopathy, free energy phenomena involving over-unity phenomena related to the dissociation of water, lightning and ball lightning, anomalous effects associated with rotating magnetic systems, phenomena related to UFOs (light balls), even remote mental interactions. One must have unified explanation for all these phenomena based on a real theory. This excludes zero point energy (ZPE) type models based on ad hoc solution of a mathematical problem with no hints about how ZPE would interact with matter.

Plasmoid as primitive life form would the underlying connecting thread between these phenomena so that all the listed phenomena would involve life and prebiotic (or possibly postbiotic!) life. This gives very strong constraints on the model. Plasmoid should consists of the analogs of linear biomolecules, it should metabolize and communicate, in TGD Universe it should have magnetic body, and even genetic code might be realized. In particular, the simplified analog of biological metabolism would be at work. In living matter photosynthesis relies on the splitting of water whereas cell respiration relies on the reversal of this process producing carbon di-oxide and water. Something very similar should happen in free energy systems involving electrolysis, and the fact that water splitting occurs also in several free energy phenomena suggests that these processes are analogous to photosynthesis and store energy to "molecules" analogous to various linear biomolecules, in particular sugars. Even the counterpart of ADP-ATP process might be realized.

In the sequel I will consider a TGD inspired model based on the notion of dark matter identified as hierarchy of quantum coherent phases with non-standard value of Planck constant given by $h_{eff} = n \times h$. The basic proposal - motivated originally by quite different experimental anomalies - is that water contains a dark component consisting of dark proton strings representing dark nuclei in nuclear string model [K10, K8, K15]. The plasmoids would consist of ring like structures formed by exotic water molecules for which second H is dark: these dark protons would combine by color bonds to from ring like dark nucleus. One cannot exclude the possibility that also other than water molecules contain dark protons: the signature would be the presence of apparently unallowed covalent bonds due to the fact the dark proton is not visible. In the following I will discuss the basic principles involved. For instance, the -H and O-H groups of carbohydrates might contain dark protons. Free energy phenomena would in this framework basically correspond to a generation of prebiotic lifeforms predicted already in the model of water memory and homeopathy [K13].

8.1 Brown's Gas

Beloved child has many names and so does also Brown's gas. Stoichiometric mixture of H_2 and O_2, HHO gas (atomic hydrogen and oxygen), hydroxy, oxy-hydrogen, electrically expanded water, charged water clusters. These names give some idea about assumptions about what might be

involved.

Brown's gas is what is created in the hydrolysis identified now as splitting of water molecules (somewhat confusingly, in biology it corresponds to splitting of molecules liberating water). It might be involved also with phenomena like steam electricity, waterfall ionization, thunder could separation, and sonoluminescence: all these phenomena involving charge separation in macroscopic scales and this phenomenon is not well understood. The lecture notes of Moray B. King (`http://www.sciencedirect.com/science/article/pii/S1875389211006079`) provide a good overall view about Brown's gas and one can also find references.

1. Brown's gas does not behave exactly like mono-atomic or diatomic hydrogen and looks like gaseous water with excess electrons. The Brown's gas flame resulting in hydrolysis is cool: the temperature is around 130 C. The flame is however able to melt metals which have roughly 10 times higher melting temperature. The flame sublimates tungsten with vaporization tempature of 5555 C, and cuts cleanly through wood, metal and ceramics. The flame does not boil water although its temperature is higher than boiling point of water.

2. The flame induces electric shock suggesting that charge or their separation in long enough scales is present. This observation brings in mind the reports of Tesla about the physiological effects caused by what he called dark currents.

3. Usual gas tends to expand but Brown's gas implodes. What this phase transition like phenomenon means is not understood but it suggests that Brown's gas is not usual hydrogen but that also second component is present. Simple but ingenious experiments manage to separate this component and it turns out that it is than ordinary hydrogen gas.

4. Brown's gas is reported to affect radio-actvity. For instance, neutralization of radioactive wastes is reported. Low energy nuclear reactions (cold fusion) and nuclear transmutations are also associated with Brown's gas. This suggests a direct connection with low energy nuclear reactions (LENR, cold fusion).

5. Brown's gas involves unknown component. This can be demonstrated in several manners.

   (a) Fill balloon with the Brown's gas and waiting it to fall to ground as hydrogen leaks out. What remains still exhibits balloon torch.

   (b) Fill paper bag with the gas. Seal bag shut. Wait 12 hours for hydrogen to vent away. Open the bag. A gains heavier than air remains and can be ignited.

   (c) Glass pouring test. Gas is heavier than air and can be poured from glass to another one. Ignite the gas at the bottom of the glass.

6. George Wiseman has observed that Brown's gas burns downward in an imploding ring. This has probably motivated the term "Electrically Expanded Water".

Charged water clusters forming vapour is one proposed identification of the Brown's gas. The motivation comes from the fact that laboratory analysis finds only little hydrogen in the flame. What remains is proposed to consist of gaseous charged water clusters. Charged water cluster have been noticed to be analogous to plasma cluster and microscopic ball lightning. The charged water clusters would behave like Rydberg matter (`http://en.wikipedia.org/wiki/Rydberg_matter`) involving core ions and de-localized electrons at circular orbits with large value of the principal quantum number n known as Rydberg orbits.

There is analogy of charged water clusters with two poorly understood phenomena: steam electricity [H5] (`http://www.esdjournal.com/techpapr/prevens/previndx.htm`) and waterfall ionization. Also thunder cloud charge separation and sonoluminescence might involve the formation of charged water clusters.

According to Moray B. King [H3] charged water clusters are formed in the cavitation of water. Cavitation can be induced either mechanically or by electric pulsing using strong electric field having interpretation as a modulation of carrier frequency by the pulse frequency. King [H1] (`http://www.free-energy-info.co.uk/MorayKing.pdf`) has discussed the possibility that charged water clusters are plasmoids, whose basic units are linear closed ring like structures consisting of sequences...-O-H-O-..... From the view point of chemistry the problem is that the bonds

do not have interpretation as covalent bonds. The stoichiometry would be also HO rather than H_2O, which leads to ask where the second H resides.

In TGD framework it would be highly desirable to assign to plasmoids dipole magnetic field and corresponding magnetic body but the proposed structure does not suggest any obvious identification of the needed ring current. The hint comes from the observation that 1/4: th of protons of water in atto-second time scale are dark in the sense that they are not visible in electron scattering and neutron diffraction. Maybe the rings are actually sequences of exotic water molecules for which the second proton is dark in some sense.

An alternative possibility is that - in accordance with the original model for $H1.5O$ stochiometry of water [K13] - these sequences are just dark proton sequences at the magnetic flux tubes associated with the exotic blob of water carrying negative charge. The protons would be outside the blob at magnetic flux tubes so that charge separation would result. This picture is forced by the findings of the group led by Gerald Pollack [I3].

To summarize: Brown's gas seems to involve two components. The other one is ordinary hydrogen and second one something heavier than air and responsible for the strange properties of Brown's gas. The basic properties of Brown's gas to be explained are electric expansion, implosion, over unity energy production, low temperature contra ability to melt metal, and the presence of a component heavier than air.

8.2 Pollack's Findings About Fourth Phase Of Water

What is described above was the view about Brown's gas before I received a link to a Youtube lecture by Gerald Pollack about fourth gel like phase of water (see `https://www.youtube.com/watch?v=i-T7tCMUDXU`) [I3]. Listening this lecture provided considerable support for this picture and led to a much more detailed and also simplified view.

The discovery of negatively charged exclusion zone formed in water bounded by gel phase was the motivation for Pollack to propose the notion of gel like fourth phase of water. Below I discuss this notion from TGD point of view.

The proposal will be that the fourth phase corresponds to negatively charged regions - exclusion zones - with size up to 100-200 microns generated when energy is fed into the water - say as radiation, in particular solar radiation. The stoichiometry of the exclusion zone is $H_{1.5}O$ and can be understood if every fourth proton is dark proton residing at the flux tubes of the magnetic body assignable to the exclusion zone and outside it. This leads to a model for prebiotic cell as exclusion zone. Dark protons are proposed to fork dark nuclei whose states can be grouped to groups corresponding to DNA, RNA, amino-acids, and tRNA and for which vertebrate genetic code is realized in a natural manner [K13, K15]. The voltage associated with the system defines the analog of membrane potential, and serves as a source of metabolic energy as in the case of ordinary metabolism. The energy is liberated in a reverse phase transition in which dark protons transform to ordinary ones. Dark proton strings serve as analogs of basic biopolymers, and one can imagine analog of bio-catalysis with enzymes replaced with their dark analogs. The recent discovery that metabolic cycles emerge spontaneously in absence of cell support this view.

8.2.1 The findings

One can find a biographical sketch [I1] (`http://faculty.washington.edu/ghp/cv/`) giving a list of publications containing items related to the notions of exclusion zone and fourth phase of water discussed in the talk. I list below some basic experimental findings about fourth gel like phase of water made in the laboratory led by Gerald Pollack [I3].

1. In water bounded by a gel a layer of thickness up to 100-200 microns is formed. All impurities in this layer are taken outside the layer. This motivates the term "exclusion zone". The layer consists of layers of molecular thickness and in these layers the stoichiometry is $H_{1.5}O$. The layer is negatively charged. The outside region carries compensating positive charge. This kind of blobs are formed in living matter. Also in the splitting of water producing Brown's gas negatively charged regions are reported to emerge [H3, H1].

2. The process requires energy and irradiation by visible light or thermal radiation generates the layer. Even the radiation on skin can induce the phase transition. For instance, the

blood flow in narrow surface veins requires metabolic energy and irradiation forces the blood to flow.

3. The layer can serve as a battery: Pollack talks about a form of free energy deriving basically from solar radiation. The particles in the layer are taken to the outside region, and this makes possible disinfection and separation of salt from sea water. One can even understand how clouds are formed and mysteries related to the surface tension of water as being due the presence of the layer formed by $H_{1.5}O$.

4. In the splitting of water producing Brown's gas [H3, H1] having a natural identification as Pollack's fourth phase of water the needed energy can come from several alternative sources: cavitation, electric field, etc...

8.2.2 Dark nuclei and Pollack's findings

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

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

2. An interesting question is whether the magnetic body is created by the electronic currents or whether it consists of flux tubes carrying monopole flux: in the latter case no currents would be needed. This is obviously purely TGD based possibility and due to the topology of CP_2.

3. This means that in the model inspired by the lectures of Moray B. King discussed above, one just replaces the sequences of partially dark water molecules with sequences of dark protons at the magnetic body of the $H1.5O$ blob. The model for the proto-variants of photosynthesis and metabolism remain as such. Also now genetic code would be realized.

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

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

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

8.2.3 Minimal metabolic energy consumption and the value of membrane potential

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

1. The Josephson radiation generated by cell membrane has photon energies coming as multiples of ZeV, where V is membrane potential about.06 V and $Z = 2$ is the charge of electron Cooper pair. This gives $E = .12$ eV.

2. There is a danger that thermal radiation masks Josephson radiation. The energy for photons at the maximum of the energy density of blackbody radiation as function of frequency is given as the maximum of function $x^3/(e^x - 1)$, $x = E/T$ given by $e^{-x} + x/3 - 1 = 0$. The maximum is given approximately by $x = 3$ and thus $E_{max} \simeq 3T$ (in units $c = 1, k_B = 1$). At physiological temperature $T = 310$ K (37 C) this gives .1 eV, which is slightly below Josephson energy: living matter seems to have minimized the value of Josephson energy - presumably to minimize metabolic costs. Note however that for the thermal energy density as function of *wavelength* the maximum is at $E \simeq 5T$ corresponding to 1.55 eV which is larger than Josephson energy. The situation is clearly critical.

3. One can ask whether also a local reduction of temperature around cell membrane in the fourth phase of water is needed.

   "Electric expansion" of water giving rise to charge separation and presumably creating fourth phase of water is reported to occur [H3, H1].

   (b) Could the electric expansion/phase transition to dark phase be adiabatic involving therefore no heat transfer between the expanding water and environment? If so, it would transform some thermal energy of expanding water to work and reduce its temperature. The formula for the adiabatic expansion of ideal gas with f degrees of freedom for particle ($f = 3$ if there are no other than translational degrees of freedom) is $(T/T_0) = (V/V_0)^{-\gamma}$, $\gamma = (f + 2)/f$. This gives some idea about how large reduction of temperature might be involved. If p-adic scaling for water volume by a power of two takes place, the reduction of temperature can be quite large and it does not look realistic.

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

8.2.4 Fourth phase of water and pre-biotic life in TGD Universe

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

1. Cell interiors, in particular the interior of the inner mitochondrial membrane are negatively charged as the regions formed in Pollack's experiments. Furthermore, the citric acid cycle, (`http://www.en.wikipedia.org/wiki/Citric_acid_cycle`), which forms the basic element of both photosynthesis (`http://www.en.wikipedia.org/wiki/Photo-synthesis`) and cellular respiration `http://www.en.wikipedia.org/wiki/Cellular_respiration`, involves electron transport chain (`http://www.en.wikipedia.org/wiki/Electron_transport_chain`) in which electron loses gradually its energy via production of NADP and proton at given step. Protons are pumped to the other side of the membrane and generates proton gradient serving as metabolic energy storage just like battery. The interpretation for the electron transport chain in terms of Pollack's experiment would be in terms of generation of dark protons at the other side of the membrane.

2. When ATP is generated from ADP three protons per ATP flow back along the channel formed by the ATP synthase molecule (`http://www.en.wikipedia.org/wiki/ATP_synthase`) (perhaps Josephson junction) and rotate the shaft of a "motor" acting as a catalyst generating three ATP molecules per turn by phosphorylating ADP. The TGD based interpretation is

that dark protons are transformed back to ordinary ones and possible negentropic entanglement is lost.

3. ATP is generated also in glycolysis (`http://www.en.wikipedia.org/wiki/Glycolysis`), which is ten-step process occurring in cytosol so that membrane like structure need not be involved. Glycolysis involves also generation of two NADH molecules and protons. An open question (to me) is whether the protons are transferred through an endoplasmic reticulum or from a region of ordered water (fourth phase of water) to its exterior so that it would contribute to potential gradient and could go to magnetic flux tubes as dark proton. This would be natural since glycolysis is realized for nearly all organisms and electron transport chain is preceded by glycolysis and uses as input the output of glycolysis (two pyruvate molecules (`http://www.en.wikipedia.org/wiki/Pyruvate`)).

4. Biopolymers - including DNA and ATP - are typically negatively charged. They could thus be surrounded by fourth phase of water and neutralizing protons would reside at the magnetic bodies. This kind of picture would conform with the idea that the fourth phase (as also magnetic body) is fractal like. In phosphorylation the metabolic energy stored to a potential difference is transferred to shorter length scales (from cell membrane scale to molecular scale).

In glycolysis (`http://www.en.wikipedia.org/wiki/Glycolysis`) the net reaction $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2(g) + 6H_2O(l) + heat$ takes place. The Gibbs free energy change is $\Delta G = -2880$ kJ per mole of $C_6H_{12}O_6$ and is negative so that the process takes place spontaneously. Single glucose molecule is theoretized to produce $N = 38$ ATP molecules in optimal situation but there are various energy losses involved and the actual value is estimated to be 29-30. From $Joule = 6.84 \times 10^{18}$ eV and $mol = 6.02 \times 10^{23}$ and for $N = 38$ one would obtain the energy yield.86 eV per single ATP. The nominal value that I have used.5 eV. This is roughly 5 to 8 times higher than $E = ZeV, Z = 2$, which varies in the range.1-.16 eV so that the metabolic energy gain cannot be solely due to the electrostatic energy which would actually give only a small contribution.

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

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

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

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

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

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

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

1. Simplest Josephson junction model for cell membrane

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

1. Josephson junctions correspond microscopically to transmembrane proteins defining channels and pumps. In rougher description entire cell membrane is described as Josephson junction.

2. The magnetic field strength at flux tube can differ at the opposite side of the membrane and even the values of h_{eff} could in principle be different. The earlier modelling attempts suggest that $h_{eff}/h = n = 2^k A$, where A is the atomic weight of ion, is a starting assumption deserving testing. This would mean that each ion resides at its own flux tubes.

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

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

1. The simplest model for Josephson junction defined by the transmembrane protein is as a two state system (Ψ_1, Ψ_2) obeying Schrödinger equation.

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

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

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

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

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

   R_2 oscillates around $sin(\Phi_0)$ and the concentration difference is coded by $\Phi 0$ taking the role of chemical potential as a phenomenological parameter.

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

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

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

2. The counterpart of chemical potential in TGD description

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

1. The most obvious possibility is that also the chemical potential actually correspond to an interaction energy - most naturally the cyclotron energy $E_c = \hbar_{eff} ZeB_{end}/m$ of ion - in this case proton - at the magnetic flux tube. Cyclotron energy is proportional to h_{eff} and can be rather large as assumed in the model for the effects of ELF em fields on brain.

2. This model would predict the dependence of the effective chemical potential on the mass and charge of ion for a fixed value of on h_{eff} and B_{end}. The scales of ionic chemical potential and ion concentrations would also depend on value of h_{eff}.

3. The model would provide a different interpretation for the energy scale of bio-photons, which is in visible range rather than infrared as suggested by the value of membrane potential.

   The earlier proposal [K12] was that cell membrane can be in near vacuum extremal configuration in which classical Z^0 field contributes to the membrane potential and gives a large contribution for ions. The problematic aspect of the model was the necessity to assume Weinberg angle in this phase to have much smaller value than usually. Furthermore, for proton the Z^0 contribution is negligible in good approximation so that this model does not explain the high value of the metabolic energy currency.

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

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

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

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

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

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

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

8.2.6 Why would charge separation generate large h_{eff}?

The basic question is whether and how the separation of electron and proton charges generates large h_{eff}? A possible mechanism emerged from a model [K30] explaining anomalously large gravimagnetic effect claimed by Tajmar et al [E5, E7] to explain the well-established anomaly

related to the mass of Cooper pairs in rotating super-conduction. The mass is too large by fraction of order 10^{-4} and the proposal is that gravimagnetism changes slightly the effective Thomson magnetic field associated with the rotating super-conductor leading to wrong value of Cooper pairs mass when only ordinary Thomson field is assumed to be present. The needed gravimagnetic field is however gigantic: 28 orders larger than that predicted by GRT. Gravimagnetic field is proportional h_{eff}^2 in TGD and if one uses h_{gr} for electron-Earth system one obtains correct order of magnitude.

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

1. By Equivalence Principle h_{gr} has the general form $h_{gr} = GMm/v_0$, where M and m are the interacting masses and v_0 is a parameter with dimensions of velocity. For three inner planets one has $v_0/c \simeq 2^{-11}$.

2. The notion of h_{gr} generalizes to that for other interactions. For instance, in electromagnetic case the formation of strong em fields implying charge separation leads to systems in which $h_{em} = Z_1 Z_2 e^2/v_0$ is large. Pollack's exclusion zone and its complement define this kind of systems and is identified as prebiotic life form.

3. Since the natural expansion parameter of perturbative expansion is the $g^2/4\pi\hbar$, one can say that transition to dark matter phase make the situation perturbative. Mother Nature is theoretician friendly.

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

1. EZ carries very large negative charge with positive charge outside the exclusion zone.

2. TGD interpretation is in terms of $H_{1.5}O$ phase of water formed when every 4: th proton is transferred to magnetic body as dark particle with large value of h_{eff}. The proposal is that primitive life form is in question.

3. The pair formed by EZ and its complement could have large value of $h_{eff} = h_{em} = Z^2 e^2/v_0$.

4. The velocity parameter v_0 should correspond to some natural rotation velocity. What comes in mind is that complement refers to Earth and v_0 is the rotation velocity at the surface of Earth. The prediction for h_{eff} would be of order $h_{em}/h = 4\pi\alpha Z^2 \times .645 \times 10^6 \simeq 5.9 \times 10^4 Z^2$.

5. Cell membrane involves also large charge separation due to very strong electric field over the cell membrane. Also now dark phases with large h_{em} or h_{gr} could be formed.

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

1. I have speculated earlier [K14] that the rotating shaft of a molecular motor associated with ATP synthase plays a key role in generating dark matter phase. What comes in mind is that charge separation takes place associating exclusion zone with the shaft and the rotational velocity v_0 of the shaft appears in the formula for h_{em}. Of course, some numerical constant not far from unity could be present. The electric field over the mitochondrial membrane generates charge separation. One can imagine several identifications for the product of charges. The charge Z associated with the complement would be naturally associated with single dark flux tube containing dark nucleon consisting of dark protons. For instance, the charge associated with the exclusion zone could be the charge of the electronic Cooper pair giving $h_{em} = 2e \times Z/v_0$.

2. The value of v_0/c is expected to be of order 10^{-14} from the angular rotation rate of ADP synthase about few hundred revolutions per second. The order of magnitude for h_{em} could be same as for h_{gr} associated with Earth-particle system.

$h_{eff}(ATPsynthase) = h_{gr}(2e, Earth)$ would make possible reconnection of electromagnetic flux tubes with gravimagnetic flux tubes [K18].

8.2.7 Which came first: metabolism or cell membrane?

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

1. The above view suggests that both approaches are correct to some degree in TGD Universe. Both metabolism and genetic code realized in terms of dark proton sequences would have emerged simultaneously and bio-chemistry self-organized around them. Dark proton sequences defining analogs of amino-acid sequences could have defined analogs of protein catalysts and played a key role in the evolution of the metabolic pathways from the primitive pathways involving only the phase transition between ordinary water and fourth phase of water.

2. There is very interesting article [I2] reporting that complex metabolic pathways are generated spontaneously in laboratory environments mimicking hot thermal vents. Glycolysis and pentose phosphate pathway were detected. The proposal is that these pathways are catalyzed by metals rather than protein catalysts.

3. In standard biology these findings would mean that these metabolic pathways emerged before basic biopolymers and that genetic code is not needed to code for the metabolic pathways during this period. In TGD framework dark genetic code [K13, K15] would be there, and could code for the dark pathways. Dark proton strings in one-one correspondence with the amino-acid sequences could be responsible for catalysts appearing in the pathways. Only later these catalysts would have transformed to their chemical counterparts and might be accompanied by their dark templates. One cannot even exclude the possibility that the chemical realization of the DNA-amino-acid correspondence involves its dark analog in an essential manner.

8.3 A Model For Brown's Gas

The simplest TGD inspired model for the Brown's gas combines three phase transitions taking place for the space-time sheet at which particle has suffered topological condensation. The first is the increase of Planck constant by factor 2^n and second its reverse (electric expansion and implosion). The third phase transition is reduction of Planck constant combined with a compensating increase of the p-adic length scale so (liberation of ZPKE or its magnetic analog) as usable energy.

Both expansion and implosion happen. Expansion could correspond to h_{eff} increasing phase transition for water or some protons of water giving rise to strings made of dark protons in TGD inspired model of dark matter. Implosion could correspond to the inverse of this phase transition. These transitions would preserve ZPKE or its analog. The liberation of ZPKE or its analog could take place in a phase transition reducing $h_{eff} = 2^k h$ back to h but increasing the p-adic scale for the space-time sheet by factor $2^{k/2}$ (in excellent approximation) so that the size of the space-time sheet would not be affected but vacuum energy would be reduced.

8.3.1 Three possible models for liberation of metabolic energy

One can imagine three different models for the liberation of metabolic energy.

1. The simplest TGD based model is as a phase transition increasing the value of p-adic prime p assignable to the space-time sheet at which particle is topologically condensed:

   (a) Particle drops to a larger space-time sheet with larger p-adic prime p_1 with $p_1/p \simeq 2^k$. The problem is that different particles need not drop simultaneously so that coherent liberation of energy is difficult to achieve.

   (b) The space-time sheet itself suffers a phase transition increasing its p-adic length scale. The energies are scaled down by factor 2^{-k} and the difference is liberated as usable energy. Coherent liberation of energy is achieved automatically. If the particle insider the space-time sheet is free in good approximation a model as particle in box applies and if the expansion of the space-time sheet takes place adiabatically the quantum numbers characterizing the state of the particle do not change in the transition. As

a consequence, the energy $E_{\{n_i\}} = k\sum_i n_i^2\hbar^2/2mL_p^2$ is reduced as $L_p \propto \sqrt{p}$ increases to L_{p_1}, where $p_1/p \simeq 2^k$ holds true. The difference of vacuum energies is liberated as usable energy in coherent manner: this is of special significance in living systems.

2. The space-time sheet could also carry magnetic energy and particles are expected to be in cyclotron states and perhaps form a cyclotron Bose-Einstein condensate. In this case the phase transition reduces the value of B but preservers the magnetic flux so that $B \to B/2^k$, $p_1/p \simeq 2^k$, takes place. This scales down the energies of cyclotron states by the same scaling factor 2^{-k} as in the case of free particle. The liberated energy is in good approximation just the cyclotron energy for large enough values of k. Coherence is achieved automatically.

3. The earlier model for the liberation of cyclotron energy was based on the assumption that the value of B is not changed but that the value of magnetic quantum number n changed. If n is reduced one achieves liberation of energy. Coherence of the transition might produce problems now. Both models can explain the observations of Blackman and others concerning the effects of ELF radiation on vertebrate brain since the spectrum of photons energies inducing effects correspond to cyclotron energies for the latter option and in excellent approximation to it for the previous model. The mechanism is however quite different.

This phase transition for the larger space-time sheet can take place in two steps.

1. First a phase transition increasing h_{eff} of the background space-time sheet by $n = 2^k$ occurs. This leaves ZPKE invariant but scales up the size of the space-time sheet by $2^{k/2}$. The interpretation would be as "electric expansion" of Brown's gas. No energy transfer takes place since both kinetic and magnetic energies are invariant under the scaling of $\hbar$. Note however than in the original situation the magnetic field can be very strong so that zooming up from microscopic scales can happen.

2. After this a phase transition reducing Planck constant back to h but increasing p-adic length scale by 2^k occurs. The size scale of the background space-time sheet is not affected but the zero point kinetic energy is reduced by factor 2^{-k} and liberated as usable energy. This phase transition would take place for the dark component of Brown's gas in the melting of the metal and other similar phenomena. Also the liberation of metabolic energy in living matter could correspond to this phase transition.

This model for electric expansion, implosion, and energy liberation assumes nothing about the particles involved since dark particle means ordinary particle topologically condensed on dark space-time sheet and having wave function de-localized in the n-sheeted structure. For instance, water can be dark in this sense. One could indeed consider the possibility that the vapour phase identified as charged water cluster is just water containing positive ions H_+^3 or protons and electrons and that phase transition to large $\hbar$ phase expands the space-time sheet at which water is topologically condensed at evaporates the water. Ordinary liquid to gas transition could proceed in the same manner and involve liberation of ZPKE at the second step of the process. In the general case the binding energy involved with the formation of the denser phase could compensate for the energy gain in the increase of the p-adic prime so that the melting would require energy feed.

8.3.2 Model for the building bricks of plasmoids

I have already earlier discussed a model for dark proton sequences as primitive life forms. The observation discussed by Moray B. King inspired a more detailed formulation of the model of plasmoids identified as primitive life forms in TGD framework.

1. The key observation was that the model for dark nuclei [K15, K13], in particular dark proton, predicts counterparts of DNA, RNA, tRNA, and amino-acids and also vertebrate genetic code follows naturally. This together with nuclear string model led to the vision that life appears already at the level of dark variants of nuclei. The observed anomalous $H_{1.5}O$ stoichiometry of water in atto-second scale supports the view that dark protons appear in ordinary water.

2. This model was first introduced to explain water memory and homeopathy. The basic idea was that the process creating homeopathic remedy induces the analog of molecular evolution for the dark proton sequences, which in turn provide representations for the molecules appearing in environment. These representations would be fundamental also for the functioning of immune system of living matter. The dark life could provide R&D laboratory for living matter allowing to test say various gene candidates and transcribe them to ordinary biological DNAs if they are successful in the virtual model world. Evolution would not be random but directed just as evolution of technologies.

3. The latest step in the process [K28] was the proposal that cell membranes involve dark proton sequences providing a representation of dark DNA and connected by magnetic flux tubes to the units of DNA in genome. These two DNA representations would be identical. Quite generally, dark and ordinary biomolecules might be connected by magnetic flux tubes.

This picture does not yet provide model for the metabolism of the building bricks of plasmoids. Something very much analogous to the splitting of sugars to carbon di-oxide and water is however expected. Since carbon is not present now, this leaves only the option that the linear dark structures are nothing but exotic form of water for which the proton of one hydrogen atom of each water molecule is dark. These dark protons would combine by strong interactions to a nuclear string and O-H groups would be attached to them. The cyclic analog of DNA, RNA, or amino-acid realizing genetic code would be the outcome. The stoichiometry $H_{1.5}O$ observed in atto-second time scale would be achieved in average sense if the portions of exotic and dark water are same. The prediction is that dark water is heavier than ordinary water: the molecular weight would correspond to average length of the dark water cycle. This is consistent with the observations about Brown's gas.

Plasmoid should also possess a magnetic body. This requires a currents rotating along the cyclic structures. The obvious identification of the current is as dark supra currents assignable to dark protons so that the building bricks of plasmoid would be analogous to super-conducting rings.

8.3.3 Model for the metabolism of plasmoids

The proposed dark analogs of basic biomolecules would be created through the analog of photosynthesis involving the splitting of water to H + OH followed by $H \to H_{dark}$ and by recombination to a sequence of dark water molecules. The process would be analogous to translation of mRNA to amino-acids and could proceed by an analogous mechanism. The process would be spontaneous since the energy of cyclotron states would not change in $h \to h_{eff} = 2^k \times h$.

Metabolic energy would be liberated in the decay of the exotic water back to water with $h_{eff} = h$ and p-adic prime scaled by about 2^k. This process is completely analogous to the splitting of various linear biomolecules in metabolism in order to obtain metabolic energy. This process would explain the ability of cool Brown's gas to melt metal for instance. When fossil fuels are used, the outcome is carbon di-oxide and water. Now only water is obtained so that this form of free energy might not contribute to the warming of environment.

The process differs from ZPE in that it does not provide any endless source of energy. Since water is in practice an unlimited natural resource, this shold not be a problem. A closed cycle at the level of visible matter is obtained only if the reverse phase transition transforming the water with $h_{eff} = h$ and p-adic prime $p_1 \simeq 2^{k/2}p$ to that with $h_{eff} = 2^k \times h$ and p-adic prime p takes place spontaneously.

The irradiation with carrier frequency f_h and modulation frequency f_l such that one has $f_l/f_h = 2^k$ is one possibility which I have proposed. Dark solar radiation at magnetic flux tubes with magnetic field $B_{end} = .2$ Gauss (guess from the experiments of Blackman [**?**] ; also many other values can be considered) could provide automatically the needed pulsed radiation inducing the phase transition. The most optimistic option is that this transition occurs even in the case of closed system in which water circulates.

Before attempting to identify reasonable candidates for f_l and f_h it is useful to consider estimates for $h_{eff}/h = 2^k$. Note that this assumption might be too strong: the vision about evolution as emergence of number theoretical complexity suggests that so called Fermat integers defining polygons, which are constructible using ruler and compass, define favored values

of $h_{eff}/h = n$ [K10]. These integers are expressible as products of different Fermat primes $F_n = 2^{2^k} + 1$ and power of 2. The known Fermat primes correspond to $k = 0, 1, 2, 3, 4$ and are $3, 5, 17, 257, 65537$. Only the two lowest ones differ significantly from power of two.This raises the question whether also the scale hierarchies $\sqrt{3}L(k)$, $\sqrt{5}L(k)$, and $\sqrt{15}L(k)$ are important besides p-adic length scale hierarchy $L(k) = 2^{k/2}R_{CP_2}$. They could be associated with the algebraic extensions of p-adic numbers involving $\sqrt{3}$ and $\sqrt{5}$.

1. The condition that cold nuclear fusion is possible via the TGD based mechanism requires dark variant of weak interactions corresponds to scaled up p-adic length scale of order atomic size. The condition that weak bosons are effectively massless in atomic length scale gives one estimate for h_{eff}/h. The condition that weak scale characterized by M_{89} is increased to that characterized by M_{127} gives $h_{eff}/h = 2^{48} \simeq 2.8 \times 10^{14}$.

2. Second estimate for h_{eff}/h follows from the condition that cyclotron energy for given charged particle is of the order of metabolic energy quantum. For proton $B_{end} = .2$ Gauss gives $f_c = 300$ Hz. The energy is about.5 eV for $h_{eff}/h = 1.37 \times 10^{14}$ rather near to $h_{eff}/h = 2^{47}$ which is by a factor of 1/2 smaller than the previous estimate. It is however clear that the estimates are internally consistent: skeptic would see this as a pure accident and some-one taking anthropic principle seriously as an outcome of evolution in very general sense. Note that for electron the metabolic energy quantum would be about 938 eV suggesting that keV energy scale assignable to the dark weak interactions has its own metabolic energy quantum.

   For ion of mass number A and ionization z the value producing the same value of metabolic quantum is $A/z \times 1.37 \times 10^{14}$. An alternative assumption is a hierarchy of metabolic quanta coming as z/A multiples of the fundamental metabolic energy quantum for a fixed value of h_{eff}/h. The condition that the metabolic energy quantum is above thermal energy of photon at physiological temperature for which peak wavelength for blackbody radiation corresponds to energy of .13 eV. This gives $A/z \leq .5/.13 = 3.84$. The estimate is too stringent since Ca^{++} with $A/z = 20$ should allow metabolic energy quantum above the thermal energy. This suggests that h_{eff}/h characterizes given ion and that its multiples coming as power of two are allowed.

3. For $h_{eff}/h = n = 2^{k_{dark}}$ with$k_{dark} \in \{47, 48\}$ dark electron would have p-adic length scale $L(k)$, $k = 127 + d_{dark} \in \{174, 175\}$. This corresponds to a Compton length $l_c \in \{28, 40\}$ μm. That this corresponds to the size scale of cell gives additional support for the vision. Note also that for electron the size scale of CD identified as secondary p-adic time scale associated with $M_{127} = 2^{127} - 1$ corresponds to.1 seconds, which defines a fundamental biorhythm. Proton Compton length would be scaled to the range $[15, 21]$ nm (10 nm defines the thickness of the cell membrane) and light current quarks with energy of 5-20 MeV to the size scale of cell nucleus.

A reasonable guess is that the candidates for f_h and f_l should satisfy the condition $f_h/f_l = 2^k$, $k = 47$ or $k = 48$. f_h can be deduced from the estimate for h_{eff}.

1. Schumann frequency 7.8 Hz is the first candidate for the modulating frequency. This would give UV frequency $f_h \simeq 1.1 \times 10^{15}$ Hz corresponding to energy of 9.7 eV for $k = 47$, which corresponds to the energy scale for covalent bonds. The energy scale of hydrogen atom is 13.6 eV.

2. For the cyclotron frequency of DNA (which depends only weakly on the length of the DNA sequence due to the constant charge density per unit length) of about 1 Hz (the frequency of heart beat) one would obtain $f_h = 1.4 \times 10^{14}$ Hz for $k = 47$, which corresponds to energy of 1.4 eV and is just below the visible range starting around 1.65 eV. The scaling of this energy by $\sqrt{3}/2$, $\sqrt{5}/4$, and $\sqrt{15}/4$ By multiplying the For $k = 48$ the energy would be to 3.3 eV, which is quite near to the UV end 3.36 eV of visible portion of spectrum. Again one can ask whether just accidents are in question.

   Allowing the generalization of the p-adic length scale hypothesis one obtains 7 photon energies in the visible range corresponding to the scalings of 1.4 eV by $[\sqrt{3/2}, \sqrt{5/4}, \sqrt{5/2}, , \sqrt{15/4}, \sqrt{3}, 2, \sqrt{15/8}, \sqrt{5}]$ giving $E/eV = [1.71, 1.57, 2.21, 1.91, 2.42, 2.71, 2.80, 3.13]$. Note that 2 eV corresponds to red

light and metabolic energy quantum of.50 eV to $k = 51$. An interesting question is whether these special frequencies relate to the peak wave lengths for color vision.

A macroscopic variant of photosynthesis using the possibly existing dark photons at the flux tubes of $B_{end} = .2$ Gauss [**?**] can be imagined. The flux tubes of B_{end} could correspond to those of B_E with nominal value.5 Gauss if a weakening of the field value takes place inside living matter. Note that in case of $h_{eff}/h \sim 10^{14}$ this field value would correspond to about 10^{10} Tesla for the ordinary value of $\hbar$ (a field strengths assignable to supernovas!) and assignable to electron Compton scale.

The sequences of these two phase transitions involved with dark metabolism would be very much analogous to..-ATP-ADP-ATP-... "Karma's cycle". There is also a strong analogy with breathing and even sleep-wake-up cycle and longer bio-rhythms. p-Adic fractality forces to ask whether all these rhythms involve the same dark metabolic cycle but in different scales. Increase of h_{eff} indeed corresponds to an increase of "IQ" in TGD inspired theory of consciousness and its reduction to its lowering. This could quite concretely correspond the experience of becoming tired. There is also a close analogy with the state function reduction sequence in ZEO. State function reductions occur alternatively at the opposite boundaries of causal diamond (CD) of given scale and I have proposed an interpretation in terms of generalized sleep-awake cycles.

8.4 About Implications Of The New View About What Happens In Water Splitting

The standard goal in the attempts to demonstrate free energy concept is to produce over unity effect: this applies also to water splitting. If Brown's gas is analogous to a fuel carrying energy, successful water splitting must burn Brown's gas. Rather literally, the child is thrown out with the bath water. If the TGD based interpretation is correct, the storage of Brown's gas would the correct thing to do. One should also convincingly demonstrate that Brown's gas indeed contains something else than water vapour and hydrogen, and according to Moray B. King this kind of demonstrations have been carried out.

There is an objection against the interpretation of Brown's gas as fuel. The storage of energy requires energy liberation mechanisms. One can imagine several solutions.

1. The observations about $H_{1.5}O$ stoichiometry in electron scattering and neutron diffraction indicate that the exotic water-polymers containg one dark proton per water molecule are present in water normally and their life-time is of order atto-second. If the value of h_{eff} for these water polymers increases in water splitting, the lifetime of water-polymer is expected to grow. Indeed, the simplest expectation is that the lifetime is proportional to h_{eff}. This would mean that the polymers and therefore the fuel can become stable even in human time scales. For $h_{eff} \simeq 10^{15}h$ suggested by cold fusion and observations of Blackman about the effects of ELF radiation on vertebrate brain, the lifetime would be around millisecond, which happens to define fundamental biorhythm (kHz synchrony in brain).

2. The polymers are created in water electrolysis and energy is therefore needed. The process would be analogous to what happens in the storage of metabolic energy to biopolymers involving also splitting of water (photosynthesis is the simplest example). Cold fusion, which involves also electrolysis, is one natural canddiate for the process liberating the energy.

3. Another posssible energy source are the magnetic bodies of plasmoids identified in TGD framework as candidates for primitive life forms. Plasmoids have been reported to be an outcome of the water splitting and correspond to charged water clusters. Plasmoids are typically modelled as tori and the structure of dipole magnetic field is essentially that of torus so that a connection with the notion of magnetic body emerges. Magnetic body of the system serves as a natural fuel tank in TGD inspired energy technology allowing the energy to flow to the system from larger magnetic bodies. The energy itself could originate from Sun - either as photons or as charged particles transforming to dark phase with large Planck constant at the magnetic bodies. There would be a strong analogy with photosynthesis.

8.5 Lightings And Life

One expects that the phase transition $h \to h_{eff}$ takes place as plasma phase is generated. Also the formation of plasma clusters could correspond to this of phase transitions. Ball lightnings could be seen as plasmoids for which this phase transition occurs continually as they move in air.

Lightning itself could be seen as a plasmoid travelling downwards as a di-electric breakdown near the outer surface of plasmoid, where the electric field is above the critical value for di-electric breakdown. In di-electric breakdown dark phase of matter would be generated and transform to ordinary phase with scaled up p-adic length scale so that ZPKE would be liberated and the plasmoid would preserve its high temperature. The plasmoid would propagate along path with average length of $L = 45$ m after which it would become unstable against decay producing one or more baby plasmoids. The branching tree represents a sequence or generations of plasmoids replicating in the node of this tree.

This picture conforms with the proposal that life involves in an essential manner dark matter realised as large h_{eff} phases. The phase transition reducing h_{eff} back to h and increasing p-adic prime would provide metabolic energy for primordial life forms. Solar radiation should induce the reduction of the p-adic prime p characterizing the resulting space-time sheet to its normal value.

If the transition liberating ZPKE occurs routinely in living matter as basic step of metabolism, also the reverse phase transition must take place. The simplest possibility is that solar radiation with preferred frequency induces the transition increasing $n = 2^k$ back to its original value and reducing the p-adic prime by factor 2^{-k}. The ADP$\to$ ATP process could involve this process. Therefore the fundamental role of the metabolic energy feed would be to bring back the system back to the large $\hbar$ state with smaller value of p so that its size is not changed.

8.6 Could Electrolysis Alone Produce Energy?

The obvious question is whether this process can be used to produce energy continually by recycling the water. This is possible if water can be returned to its original state without feeding energy. This is not the case. The point is that the scaling up of the size of the p-adic space-time sheet carrying water clusters must be undone and this requires compression and therefore energy. Believers in ZPE would suggest that the return to the original state takes place spontaneously by extraction of vacuum energy. One can however imagine an open system in which the water that comes in is not circulated and takes the role of fuel.

The formation nuclei formed in cold fusion has been reported in electrolysis and one can also imagine the possibility that the formation of dark phase of matter makes possible cold fusion. The proposed phase transition alone does not provide any obvious mechanism of cold fusion. One however expects more general phase transitions to dark matter be present already in water.

1. For instance, the phase transition increasing the value of h_{eff} for the electroweak field body of nucleus could increase the weak length scale fro 10^{-17} meters to about atomic length scale and below this scale weak bosons would be effectively massless and weak interactions would become strong. This together with nuclear string model inspires a possible model for how cold fusion could proceed [K15].

2. An alternative option is based on the formation dark protons with Compton length or order atomic length scale. In [K15] a more detailed quark level mechanism for how this could allow to overcome Coulomb wall in H-D cold fusion is considered. The idea is simple: increase of Planck constant zooms the space-time sheets of proton and quarks to atomic size so that the target deuteron finds itself in the interior of dark proton or one of quarks. Also anomalous selection rules explaining the absence of high energy neutrons and gamma rays are considered.

8.7 Comment About Hydrinos

Randell Mills [D8] has claimed on basis of published experimental findings that hydrogen atom allows what he calls hydrino states. For these states the principal quantum number n characterizing the energy of the state completely is replaced with its inverse $n \to 1/n$. This implies that the binding energy spectrum $E \propto 1/n^2$ is reverted to $E \propto n^2$. A more general hypothesis is that

scaling $E_n \propto 1/n^2 \rightarrow m^2/n^2$ takes place. The most probable reason for not taking the claim seriously is that neither Schrödinger equation or Dirac equation allows this kind of states.

Could non-standard value of Planck constant explain the claim of Mills?

1. The naive approach would just replaced h with $h_{eff} = mh$ in the formula for the binding energies. The proportionality $1 \propto 1/h^2$ would imply the reduction of the binding energies by factor $1/m^2$ rather than its increase by factor m^2. This naive modification of the basic formulas is however not consistent with the fact that the formula for the binding energy is non-perturbative as the fact that binding energy becomes infinite at the limit $h \rightarrow 0$. One must modify Schrödinger equation itself rather than only the quantum numbers appearing in it.

2. I have considered the possibility that the introduction of large Planck constant $h_{eff} = mh$ corresponds to $1/m$-fractionization for quantum numbers and that anyons for which this fractionization takes place could be understood in TGD framework. One could start from fractionization for the angular momentum and the radial "momentum" n. Replacing n by n/m one indeed obtains formula $E_n \rightarrow m^2 E_n$ more general than but consistent with that of Mills. One might hope that a modification of Schrödinger equation gives this result at least approximately.

3. One can indeed consider a modification of the Laguerre equation for the radial part of the electron's wave function in hydrogen atom with quantum Laguerre (q-Laguerre) equation. This is well-motivated if $h_{eff} = mh$ corresponds to $1/m$-fractionization for quantum numbers and this is one of the basic ideas related to the interpretation of h_{eff} hierarchy. I have studied q-Laguerre numerically for years ago (`http://tgdtheory.fi/public_html/freenergy/freenergy.html#freenergy` [K22]). The formula of Mills can be produced approximately fr $m > 2$ but nor for $m = 2$. Hence the scaling of the ground state binding energy by 4 cannot be understood unless one assumes that it is produced from $n = 2$ state for $m = 4$.

The connection with hierarchy of Planck constants and fractionization of quantum numbers is far from being well understood so that q-Laguerre equation could be also seen as an independent hypothesis. q-Laguerre equation is application of quantum group concept closely related to von Neuman algebras known as hyper-finite factors of type II_1 (HFFs) providing alternative mathematical framework for quantum theory. In TGD framework [K25] these algebras relate naturally to the notion of finite measurement resolution. The question is whether there really is a connection between finite measurement resolution realized in terms quantum group concept and inclusions of HFFs and hierarchy of Planck constants.

At the level of numbers the correspondence would mean that quantum group characterized by quantum phase $q = exp(i2\pi/n)$, $n = 3, 4, 5, ...$ corresponds to $h_{eff} = nh$ and to a discretization of angle variables so that only the phases $q^k = exp(i2\pi k/n)$ appear in the phase resolution used (in purely p-adic context only the phases make sense, not angles). Note that $n = 2$ is not in the series of the allowed quantum phases: therefore it is not surprising that $m = 2$ is problematic in q-Laquerre equation.

A strong objection against this proposal is that all previous arguments suggest rather large values of h_{eff}/h: now the values would be rather small. My personal guess is that the electrolysis effects found by Mills can be explained by the general model already discussed without hydrino hypothesis.

8.8 Does Dark Biology Represent Pre- Or Post-Biotic Evolution?

The discovery of dark proton realization of genetic codons [K15, K13] was an accident and I am still puzzled about whether the vertebrate genetic code can really emerge from dark nuclear physics or is it only a curiousity or self deception. The first interpretation for the dark code is as a code associated with prebiotic evolution [K11]. This is suggested by the enormous simplicity for the analogs of counterparts of linear biomolecules, and the fact that the utilization of metabolic energy means that these "molecules" decay to ordinary water. In this view life would have migrated from dark space-time sheets to visible space-time sheets. This higher level life would be gradually

migrating to lower levels in the hierarchy and taking visible matter to its control and that biological evolution represents a step in this process.

There are however some objections against this view. The dark code corresponds to vertebrate code, which can be seen as an outcome of along genetic evolution. There are also other codes, which are less perfect (thes are discussed in [K4] representing a number theoretic approach to genetic code). For instance, the meaning of the codeword is context dependent for some codons and Peter Gariaev has proposed that this context dependence is a more general phenomenon. One would expect that prebiotic code is much simpler than genetic code and I have considered a model for how genetic code might have emerged from more primitive codes with 4 and 16 code words as a "product code" [K4, K11].

These objections inspire the question whether life could migrate from lower to higher scales. The dark genetic code would in this framework correspond to the emergence of a new level in evolution - perhaps identifiable as cultural evolution. This would explain why dark variant of the genetic code corresponds to vertebrate code. One could also solve Fermi paradox [K24] due to the fact that no signs of intelligent life have been observed in cosmos and probabilistic estimate suggests that cosmos is full of life. The answer could be very simple: in some stage the civilization transforms to dark matter invisible to us! The civilizations are there but living on magnetic flux quanta and probably communicate with us telepathically. The higher evolutionary level would also conform with the fact that the spatial and temporal scales of consciousness are much longer than for the consciousness assignable to visible manner. This could allow also to understand also the mystery of crop circles. To my opinion many of them are genuine, and the interpretation as some kind of cognitive representations analogous to those realized in brain is highly suggestive. Certainly these representations would represent mental images of conscious entities, which are at higher evolutionary level than us [K5, K6].

Many great leaps in evolution have occurred via crisis periods involving extinction. Could it be that gradual transition to dark matter based life could be begin as a response to the recent crises of human kind? The gradual transition of life to the dark matter level would indeed solve the energy problem by coupling us to the energy sources assignable to the dark matter hierarchy at various magnetic bodies. It would also solve the problem caused by the climate warming if it is indeed is due to the liberation of CO_2 as fossil fuels are used. The dark matter "molecules" as analogs of biomolecules and hydrocarbons would produce only water when used.

What has been bothering me somewhat are the messianic elements of free energy movement: something totally new is believed to be emerging even at the level of consciousness and ethics and moral rules. Skeptic scientist finds it difficult to accept the idea that new form of energy could have so wide implications: the fundamental problems of the society relate to ethics and moral. On the other hand, if one interprets free energy phenomena as manifestations of post-biotic life forms realizing genetic code at the level of dark matter, it becomes possible to defend the messianic view about free energy. The transition to dark matter dominated world would mean also leap in the level of consciousness.

The belief in ZEP has also some features that worry me. I believe that there is some great intuition behind this view but to me its realisation in terms of ZEP is wrong thing to do: the existing mathematical physics simply fails to provide the needed language and concepts. My own proposal is zero energy ontology (ZEO) in which physical states are replaced with physical events and continual re-creation becomes possible without giving up the symmetries and laws of physics.

I find it also alarming that some advocates of free energy also have a hostile attitude towards science. This is easy to understand as a reaction to the arrogant attitude of the academic world towards free energy and actually all visions challenging the basic dogmas of the standard science. Christianity emerged as the Roman Empire collapsed and something similar seems to happening now: at this time free energy movement might take the role of Christianity. It would be a pity if also now blind beliefs would replace rational thinking for almost two millenia.

9 The "impossible" EM drive

NASA's impossible EM drive has appeared in Facebook again and again (see `http://tinyurl.com/hq7vd3a` as an example), and I finally lost my patience and decided to learn what it is involved. The Wikipedia article (see `http://tinyurl.com/zkwoehe`) describes the EM drive and gives a lot

of references. The original skepticism by mainstream is probably changing to a real curiosity after several replications.

9.1 Basic facts about EM drive

First some raw data from the Wikipedia article.

1. According to Wikipedia article, Roger Shawyer, who is behind the concept of EM drive, has claimed that the prototype produces a total thrust about .02 Newtons using the power by 850 W magnetron. To get some perspective note that in order to move 1 kg weight with the velocity of 1 m/s in the gravitational field g= 10 m/s^2, a power of 10 W is required so that the construction might be scalable. The device could operate only few dozen seconds after the magnetron failed due to overheating. Therefore the hypes abut travels to Moon within few hours should be taken cautiously!

2. There would be no fuel in the conventional sense of the word. Basic conservation laws of momentum and energy however require that if system gains momentum there must be another system gaining opposite momentum. For ordinary rocket this would be exhaust fuel. No exhaust has been observed and this is thought to make the drive "impossible". For instance, NASA researchers talk about "quantum vacuum virtual plasma" as the system with which the momentum would be exchanged. Also energy is needed. The magnetron would provide this energy.

The theory of Shawyer for EM drive can be found at `http://tinyurl.com/zkwoehe`. The basic idea is very simple.

1. Consider first an ordinary rocket. The fuel explodes and liberates chemical energy and part of exhaust products are allowed to leave the rocket, which experiences the reaction force and gains momentum. One can also modify this rocket a little bit. This is not practical but serves a noble pedagogical purpose. Allow the fuel leak out in opposite directions but in such a manner that the leakage is smaller in the second direction. Rocket accelerates also now since the two forces due to the leakage do not cancel each other.

2. Next do some abstraction. What matters are conservation laws are energy and momentum, not the medium which carries them. Replace fuel with microwaves in a microwave cavity reflecting forth and back and having energy but no net momentum. Replace the fuel tank by magnetron producing the radiation.

   Arrange the situation so that the leakage of momentum is realized as radiation pressure, which is different at the ends of cavity. For the ordinary fuel this is not a problem and it is difficult to see why it should be so for em fuel. This em fuel would be produced by magnetron in cyclotron transitions with cyclotron transition frequencies equal to resonance frequencies of the microwave cavity. This requres tuning of of the strengths of magnetic field and length of cavity. System would be critical in this sense.

3. The asymmetry between ends realized somehow would create a net force on the system as difference of the forces at the ends of the cavity. One could interpret this also by saying that the reaction force forces the system to move. The needed momentum exchange would be between radiation field and rocket. Microwave energy and also a net momentum leaves the system just like momentum carrying fuel from ordinary rocket. The dimensionless Q value characterized the flow of energy out of the system. Also the flow of momentum at the ends of the cavity would be proportional to Q.

4. The claim of Shawyer (see `http://tinyurl.com/zkwoehe`) indeed is that the net forces (pressure times area) at the two ends are different. This would be due to the different group velocities assignable to classical em field at the two ends of the cavity and also due to different area. The argument is that at the smaller end (disk) the group velocity of wave is lower due to the fact that the reflections from the walls of the cavity occur more often so that paths of photons become more zigzagged and the net propagation for energy becomes slower. This argument makes sense to me. Of course, to really understand whether this is the case, would require a detailed modelling of the situation.

9.2 The problem and its solution in TGD Universe

What is then the problem?

1. It is argued that the construction breaks momentum conservation. If microwave photons leak out they should heat the cavity and the energy and momentum would leak out as thermal radiation. Is it that this radiation is not observed or is the heating theoretically so small that it cannot be observed? There is however the heating of magnetron, which forces to stop the experiment. As if the energy and momentum would go to the magnetron! Could this microwave energy be enough to achieve the heating of magnetron? Microwaves are indeed used for heating and they might be able to do this. But how the leaking energy and momentum could end up back to the magnetron?

2. Recall that in the experiments of Russian physicists in which magnetic motor was claimed to start spontaneously acccelerate in in its rotational motion similar breakdown was the problem [K1]. Similar breakdown plagues also Yildiz motor [K1]. I have proposed for both systems a TGD based model involving the magnetic body (MB) of the motor and dark photons and particles. What could cause this breakdown? Could it be that energy and momentum that should have left the system is actually feeded to the magnetron via its MB consisting of flux tubes serving as channels?

9.2.1 Magnetron

To understand what might be involved consider what magnetron is (see `http://tinyurl.com/cmlg9gf`).

1. Magnetron produces the microwave radiation and serves obviously as the energy producer. The operation principle of magnetron is as follows. One has two electrodes - the negatively charged catode and the positively charged anode - at the opposite ends of a cavity (not the microwave cavity) with some length L. Constant electric field is generated between elecrodes. Electrons flow from catode to anode in this electric field. One adds a magnetic field orthogonal to the plane of the motion for electrons. This fields forces electrons orbits to curve in the plane orthogonal to the magnetic field.

2. There is a critical value of magnetic field for which electrons just reach the anode. For stronger magnetic field they turn backwards before reaching the anode. Magnetron operates using this critical field. Note that resonance condition defines second criticality condition. Cyclotron photons created in magnetron have frequency, which corresponds to a resonance frequency $f = nc/L$ ($c = 1$ in the sequel) of the cavity and standard quantum theory tells that their energy is given by $E = hf$. This is very small energy and it is not at all clear whether photons with this energy can cause heating of the magnetron.

9.2.2 Notions of dark matter and magnetic body

Next the TGD view about dark matter is needed [K10, K31, K20, K17].

1. Dark matter, also dark photons, has non-standard value of Planck constant $h_{eff} = n \times h$ is generated in TGD Universe in quantum critical systems, which can appear in all scales. The process can be regarded as a quantum phase transition. One experimental motivation for the hierarchy of Planck constants were the strange quantal looking effects radiation in EEG range (ELF) on vertebrate brain. The eplanation was in terms of dark $h_{eff} = n \times h$ cyclotron photons. Dark cyclotron photons have energies and therefore also momenta much larger than they should have by $E = h \times f \rightarrow = n \times h \times f$.

2. These dark photons can transform to ordinary photons and vice versa but do not appear in the same interaction vertices with particles with different value of h_{eff} - hence darkness for practical purposes. Biophotons would be example of ordinary photons produced from dark photons in this phase transition like process.

3. The associated notion is magnetic body (MB) consisting of flux tubes and flux sheets and carrying these dark protons. MB can be identified as intentional agent in biosystems and receives sensory input from biological body as dark photon signals and controls it by dark photon signals.

9.2.3 Is magnetron a quantum critical system generating dark cyclotron photons?

Could it be that magnetron is quantum critical system and generates dark cyclotron photons with large value of Planck constant?

1. Could the criticality of magnetron imply that part of the cyclotron photons created by the magnetron are actually dark and have much larger energies and momenta than ordinary photons. Could the MB of magnetron be in contact with the second microwave cavity and could the dark cyclotron photons leaking from the ends of the cavity end up to MB and from MB back to magnetron and heat it?

2. The system is claimed to not produce any visible exhaust products - that is ordinary microwave photons. Could the leaking exhaust product be dark microwave photons and thus not visible and having very large energies? Could the dark photon exhaust products end up to the magnetron by the above mechanism. Here they would partially transform to ordinary high energy photons and heat the cyclotron inducing the failure of its operation.

3. Magnetron produces high energy dark photons, maybe with energies in visible range if the model for biosystems is taken as starting point. One can argue that the description in terms of classical fields gives a realistic estimate for the total power irrespective of the value of h_{eff}. Thus the net power would not matter. Microwaves have extremely tiny energies (for 1 meter wavelength a fraction about 10^{-6} about the energy 1 eV photon, which is just below the visible range). The dark photons transformed to say ordinary high energy photons with energy of visible photons would interact with the condensed matter by inducing molecular transitions and the heating effect could be much more effective than for ordinary microwave photons. Thus one would have the primary heating of magnetron plus the heating caused by the dark photons from the microwave cavity.

4. Any owner of microwave oven can however argue that microwaves are very efficient heaters. Why dark photons would be needed? Now I cannot silence the heretic inside me. Do we really know what is happening inside our own microwave ovens? Could also this microwave heating involve dark photons with energies, which correspond to molecular transition energies? Could this be the reason for the unreasonable effectiveness of microwave ovens? Microwave ovens involve also another strange phenomenon - small but visible ball lightnings [K29]. Could the visible and UV photons resulting from dark microwave photons heat the air to form a plasma producing the visible radiation? Microwave radiation can also induce "burning" of water involving flame of visible light [K26]. I have proposed explanations of also these phenomena in terms of dark photons transforming to the analogs of bio-photons with energies in the range of molecular transition energies.

If the microwave energy and also momentum returns back to magnetron as dark microwave photons, the magnetron would receive - not only part of the energy - and also part of the momentum opposite to that obtained by the system minus magnetron. If all momentum returns to magnetron, the recoil momentum would not actually leave the system: space-flight might not succeed!

9.3 TGD view about the standing waves in wave guide

It has been proposed that the paired photons with sum of electromagnetic fields equal to zero in microwave guide should make possible the leakage of the radiation (see `http://tinyurl.com/z5quluy`. I find it difficult to make sense of this argument. This article however inspired to look the situation using TGD based view about em fields.

In photon picture photons would be reflected from the ends of the cavity and also from the side walls if the cavity is a cone cut from its ends. In reflection energy is conserved by a momentum which is twice the projection of momentum in orthogonal direction is lost. If the net losses occurring

at opposite ends are different, thrust results, even if Q value is vanishing. Only in special case the wave vectors are quantized the net momentum current at the ends of cavity vanishes (discrete translational symmetry). These situations correspond classically standing waves.

In Maxwellian theory em fields should correspond to standing waves with opposite wave vectors. Standing waves in TGD framework are not possible at single space-time sheet. Maxwellian linear superposition fails. The basic solutions are "massless extremals" describing propagation of arbitrary pulses in single direction, left or right, with maximal signal velocity preserving pulse shape [K3, K32]. Linear superposition for the pulses travelling in the same direction makes sense. This represents precisely targeted communication.

How to obtain something analogous to standing waves in TGD?

1. One can have two parallel space-time sheets in which the propagations occur in opposite directions. Tests particle (small 3-surface) touching both sheets experiences the sum of forces created by the classical fields, and this corresponds to that created by a standing wave. More generally, one can have set theoretic unions of MEs and these effective represent linear superposition of waves (actually only of their effects). This is the manner how many-sheeted space-time give rise to the space-time of standard model and GRT.

2. Suppose the cross section fo wave guide is constant. If only standing waves, that is pairs of MEs carrying momentum of same magnitude, are present, they can disappear from the wave guide only in pairs. The net value of lost momentum vanishes for each lost ME pair and it would seem that one cannot have asymmetry in the case of a wave guide with a constant cross section.

3. If the members of ME pairs have different wave vector components along wave guide the loss of ME pair means a net momentum loss. Could the reflections of MEs at the ends and walls be such that the magnitude of the momentum component in the normal direction not only changes sign but is also reduced so that also energy of photon is reduced. This could be the counterpart for the non-vanishing Q-value.

   The first ME would correspond so a sum of pulse, 2 times reflected reflected pulse, 4 times reflected pulse, etc... The second ME would correspond to sum of $2n+1$ reflected pulses and loss of ME pair would mean a net loss of momentum but it could go the walls of the cavity.

4. In cylindrical geometry the condition that one has standing waves implies $k = n2\pi/L$ so that the value of n would change in the reflection which would be like quantum transition. The lost 4-momentum would be $\Delta p_4 = (\Delta p, 2\Delta p) = \epsilon(p, 2p)$, $\epsilon < 1$ and tachyonic. This momentum could go to the wall of the microwave cavity as a whole. One can also imagine that only part of momentum is lost in this manner and that the momentum splits to part $p_1 = \epsilon(p, p)$ leaking out as dark photon and $p_2 = \epsilon(0, p)$ absorbed by the wall of cavity. This contribution would correspond to radiation pressure. Also more general momentum splittings are possible.

5. Could the lost photon with 4-momentum $\epsilon(k, k)$ go to a magnetic flux tube of magnetron as dark photon? In the general case light-like momentum $\epsilon(k, k)$ should be parallel to the flux tube and the the rest of momentum difference Δp_4 would go to the wall of cavity. If flux tube of the magnetic field of magnetron is parallel to the wall of the cavity, this is not possible. If the flux tubes are parallel to the ends of the cavity, they should absorb the entire Δp_4. This suggests that flux tubes should be nearly orthogonal to either end of the wave guide.

Armed with this picture one can try to answer the question whether one obtain net acceleration lasting the desired time.

1. Whether one can obtain a net momentum transfer to the MB of the system, depends both the shape of cavity and on the direction distribution of flux tubes and their density at surfaces orthogonal to the average magnetic field. This density is proportional to the average magnetic field. The magnetic field of magnetron is dipole field in the first approximation and the flux tubes form closed loops.

   A good position for the wave guide is such that magnetic field lines meet the second end of the wave-guide nearly orthogonally. The magnetron could be from left or right from the

wave guide, maybe nearer to the end with larger area to maximize the number of flux tubes meeting the end. One would obtain dark photons at the magnetic flux tubes leading to the magnetron and - if not else - at least an explanation for why magnetron heats up so fast!

2. Is it really possible to obtain accelerated motion in long time scale? System plus its MB does not accelerate unless MB is able to transfer its momentum somewhere, say to a larger MB. This probably poses limits on the distance which the system can move since one naively expects that system and its MB tend to move in opposite directions so that MB would stretch. One expects, that MB can store only a limited amount of momentum to say Bose-Einstein condensate of dark photons.

   The momentum transfer (as dark photons) to a larger MB would require reconnections with it. Reconnection is a standard mechanism in TGD based quantum biology [K26] relying strongly on the dynamics ("motor actions") of MB (braiding making possible topological quantum computation, reconnection making possible dynamical flux tube networks, h_{eff} changing phase transitions changing the length and the thickness of flux tubes as scales proportional to h_{eff}, ..).

What criticisms and other variants of the general idea - exchange of momentum with MB - one can consider?

1. The model of authors proposes that the classical em waves/photons are reflected from the walls of em-drives and in this process the longitudinal momentum is reduced in the direction in which the cavity gets narrower. This is an attractive idea intuitively.

   As the photon is reflected from the wall of the cavity it loses momentum and some energy. Modes are quantized by boundary conditions and the energy of mode decreases slightly. Where does the lost energy go? Since the change of energy is small and change of momentum large, the energy must go to energy of some massive particle with mass M: $\Delta E = (2k_N)^2/2M = 2(k_N/M)k_N$ so that the fraction of energy lost is smaller than $2(k/M)$ and very small. Lattice oscillations are a natural identification. The energy would be transformed to heat.

2. If part of the photons leak out at walls and ends of the cavity as dark photons the magnetic flux tubes, a net force is generated. If the magnetic field of cyclotron is vertical it can be parallel to em drive only in regions where the direction of flu tubes becomes horizontal. This might be a real problem.

   (a) Cavity could have its own dark magnetic body with dipole axis naturally parallel to the cavity. Also the electrons in magnetron turning around could send part of cyclotron photons as dark photons to the flux tubes of dark MB parallel to magnetron.

   (b) Suppose that MB - whatever it is - carries dark matter. In TGD inspired quantum biology MBs have the role of intentional agent and MB is able to self-organize in optimal shape to control the biosystem. In particular, MB soaks up metabolic energy from biological body. One can speak of symbiosis.

   Could a primitive living system form also now in such a manner that the MB of magnetron organizes in such a manner that flux tubes become parallel to the cavity at its ends? The metabolic energy could come from magnetron, which in turn could get its energy from surrounding space by some technology (the point is that no fuel is needed). In the model of rotating magnetic systems [L8] a self-organization of the flux tubes of the magnetic field generated by the magnetic system to dark magnetic flux walls is indeed assumed. The MB formed in this manner would soak up metabolic energy from the em drive.

   (c) Could the magnetic field $B_E = .5$ Gauss of Earth or the endogenous dark magnetic field $B_{end} = 2B_E/5$ playing a key role in TGD inspired quantum model of biology be involved [L7]? If the direction of B_{end} is that of B_E, the functioning of em drive depends on the orientation of the em drive unless the flux tubes of B_{end} self-organize so that they are parallel to the cavity symmetry axis.

(d) Also the flux tubes of the magnetic field - call in B_{gal} having strength of order 1 nT assigned to the intergalactic magnetic field are proposed to be fundamental for living matter: the corresponding cyclotron frequencies for ions would correspond to biorhythms longer than those of EEG up to circadian rhythm [L7]. Could the flux tubes of B_{gal} self-organize themselves parallel to the cavity?

10 Hydrinos again

I have a habit of returning to TGD explanation of various anomalies to see whether progress in TGD could allow new insights. At this time the question about whether hydrinos might be real, served as an inspiration. This led a to consider a possible connection with cold fusion and a new TGD inspired model for hydrinos. I have discussed this topic earlier at [K22, K8].

Randell Mills as written a book and numerous articles about hydrino concept and many of them are published in respected journals [D8]. The company of Mills has a homepage containing besides commercial side also list of the abstracts with links to the corresponding articles related to the experimental aspects of the hydrino concept giving a brief summary about what is known about hydrinos (see `http://tinyurl.com/hajyqo6`).

The proposal is that hydrogen atoms allows besides the states labelled by integer n also states labelled by inverse integer $1/n$. Ordinary states would have size proportional to n^2 and binding energy proportional to $1/n^2$. Hydrino would have sizes proportional to $1/n^2$ and binding energies proportional to n^2. There would be strange duality between binding energy and size of the orbit and it is difficult to imagine a modification of hydrogen atom making this possible. Not surprisingly, mainstream physicists do not accept the notion since it challenges the existing atomic model.

The most straightforward proof of the concept would be observation of a radiation emitted as ordinary hydrogen atom goes from ground state to hydrino state and emits radiation with energy $E_n \simeq n^2 E_1$, where E_1 is the ground state energy $E_1 \simeq 13.6$ eV. The natural limit for binding energies corresponds to $n = 137$: in this case binding energy becomes larger than electron mass. Also more general transitions $1/n_1 \to 1/n_2$ are predicted. (see for the table of transition energies `http://tinyurl.com/zmfma79`).

These transitions are not however observed. The explanation is that they are non-radiative transitions occurring as the catalyst molecule having energy level with same energy absorbs the emitted UV photon. The proposal is that the energy from the transition $1/n \to 1/(n+1)$ and given by $(2n+1)E_1$ goes to a many-particle state formed by n hydrogen atoms and is eventually liberated as a continuum EUV radiation (see `http://tinyurl.com/glf975u`).

Skeptic can argue that if these transitions are possible, they should occur even spontaneously, and that if catalyst is indeed necessary there must be some good explanation for why this is the case. Hence the experimental support for the hypothesis is indirect and one can consider also alternative explanations.

In any case, the articles are published in refereed journals such as European Physics Journal and the claim is that energy is produced and the technology is claimed to already exist. The energy production is explained in terms of hydrino atom.

The article *Mechanism of Soft X-ray Continuum Radiation from Low-Energy Pinch Discharges of Hydrogen and Ultra-low Field Ignition of Solid Fuels* (see `http://tinyurl.com/hdzu9np`) gives an idea about the experimental side.

The article reports EUV radiation in the wavelength range 10-20 nm (62 eV-124 eV) assigned with the transition $1/n = 1/3 \to 1/4$ of hydrino atom for which the energy of the emitted quantum would be 94.2 eV. Emission in this wavelength range was observed for electrodes containing metal oxides favorable to undergo reduction to HOH (water) catalysts so that HOH catalyst would play a significant role. A low voltage high current was passed through a solid fuel comprising a source of H and HOH catalyst to produce explosive plasma and similar EUV radiation was detected. This kind EUV radiation cannot be explained in terms of any chemical reaction.

10.1 Is there a connection with TGD based model for cold fusion?

The experiment brings in mind the experiments of the group led by Prof. Holmlid (see the popular article at `http://tinyurl.com/nbephxb`) and the slides of the talk by Sweinn Olaffsson at `http:`

//tinyurl.com/j3csy53) related to cold fusion (or low energy nuclear reactions (LENR). This work is taken rather seriously by the community and the status of cold fusion has changed. Also in this case one considers electrolyte and water is in key role. Also Coulomb explosion producing plasma is involved and claimed to produce what is interpreted asa very dense phase of condensed matter consisting of string like structure with distance between hydrogen atoms given essentially by the Compton wavelength of electron.

1. In TGD framework the atomic strings of Holmlid are replaced by nuclear strings [L6] and interpreted as dark nuclei with large value of h_{eff} meaning that the Compton length of proton is scaled up to that of electron by a factor about $h_{eff}/h = 2^{11}$.

   Could the findings of Mills et al relate to the same phenomenon as the findings of Holmlid? The effective radius of the dark nucleus is 2.4×10^{-12} meters. The radius of $n = 4$ hydrino would be 3.3×10^{-12} m so that the two phenomena might have common origin.

2. Dark nuclear binding energy is liberated as dark photons as dark protons fuse to a dark nuclear string. The naive scaling of the nuclear binding energy per nucleon would mean that it is proportional to the Compton length of nucleus and thus to $h/h_{eff} = 2^{-11}$. If nuclear binding energy is taken to be of order 1 MeV one has binding energy scale 500 eV, which is about 5-10 times higher than the energies in the energy range of EUV radiation. This would suggests that hydrino does not reduce to same physical effect as cold fusion. One must be however cautious and ready to challenge both the idea about low energy nuclear reactions and about hydrino atom as such.

3. One could however consider also other values of h_{eff}/h. Assume that they come as powers of 2. If one has $h/h_{eff} = 2^{-14}$ the Compton length is 2.84×10^{-11} m to be compared with Bohr radius 5.3×10^{-11} m. For $h/h_{eff} = 2^{-13}$ the binding energy would be about 63 eV which corresponds to the lower boundary of the energy interval. In this case the size of dark nucleus would be 4 times longer than electron Compton length. Could the phase transition take in two steps or could one have quantum criticality in TGD sense meaning that phases with several values of h_{eff} are present? Or could the experiments of Mills and Holmlid differ in that Mills detects $h_{eff}/h = 2^{13}$ case and Holmlid $h_{eff}/h = 2^{11}$ case.

4. The formation of dark proton string would give rise to emission of dark photons with nucleon binding energies of the nuclear string and its excited states formed in this manner. These dark photons are observed only if they transform to ordinary photons in the measurement volume. Their wavelength would be anomalously long - by a factor of order 2^{13} longer than the wavelength of ordinary EUV photon in wavelength range 10-20 nm and therefore in the length scale range 80 - 160 μm assignable to living cells. The transformation to ordinary photons could be by the transition $h_{eff}/h \to 1$ and absorbtion by a complex of n hydrogen atoms transforming it to continuum radiation.

5. The dark nuclei would decay eventually to ordinary nuclei and liberate ordinary nuclear binding energy. There is experimental evidence for the occurrence of this process. It is however quite possible that most of the dark nuclei leak out of the system and that the energy could be liberated in metal targets.

This if of course only a one possible model for the effect observed by Mills and TGD allows to consider also a model of hydrino based on the TGD based view about dark matter.

10.2 Hydrino as dark atom?

I have considered several models for hydrino in TGD context. One of them corresponds to a quantum group analog of Laguerre equation giving fractional spectrum for the principal quantum number n [K22, K8]. The spectrum would be more general than that proposed by Mills since one would have $n \to n/m$ rather than $n \to 1/n$.

The following considerations are inspired by the heretic proposal that hydrogen atom might not actually correspond to the smallest possible value of $h_{eff}/h = n$. This idea has popped into my mind repeatedly but I have dismissed it since I have felt that $h_{eff}/h = n$ hypothesis is already

enough to irritate colleagues beyond the border. The phase transition $n \to n_1 < n$ scales up the binding energy spectrum by factor n/n_1 and is the simplest proposal found hitherto.

The model should explain why hydrino states are generated spontaneously but require the presence of catalyst and why the photons associated to the hydrino transitions are not detected directly but only as a continuum radiation.

1. The first guess would be that hydrino corresponds to hydrogen atom with non-standard value of Planck constant $h_{eff}/h = n_h$. The problem is that the formal substitution $h \to h_{eff} = n_h \times h$ in hydrogen atom scales down the energies by $E_n \to E_n/n_h^2$ so that they decrease instead of increasing.

   One can however make a heretic question. Does ordinary hydrogen atom really correspond to the smallest possible value of $h_{eff}/h = n_{eff}$ with $n_{eff} = 1$ and thus of $\alpha_{eff} = e^2/4\pi\hbar_{eff}$? Should one take this as a purely experimental question and remember also that in perturbative approach Planck constant does not appear in the scattering rates except in loop corrections. Therefore in the lowest order the value of h_{eff} could vary. In TGD loop corrections vanish by quantum criticality and coupling constant evolution is discretized and it could be difficult to detect the variation of h_{eff}.

2. Could the ordinary hydrogen atom actually correspond to $h_{eff}/h = n_H > 1$ and therefore to $\alpha_{eff} = \alpha_R/n_H = e_R^2/4\pi\hbar n_H$ ("R" for"real") so that one would have $\alpha_R = n_H\alpha$? The convergence of the perturbation theory would dictate the value of n_H and in only special situations smaller values of n_H would be possible. This would explain why hydrogen atom does not make a spontaneous transition to the hydrino state.

   The maximal value of n_H would be $n_{H,max} = 137$ (the binding energy becomes larger than the electron mass) implying $\alpha_R \simeq 1$ for $h_{eff,R} = h/137$. For hydrino atom made possible by the presence of catalyst, the value of h_{eff} would be reduced so that the energy would be scaled up by a factor x^2: $x = h_{eff,H}/h_{eff,h} = n_H/n_h$: here "$\hbar$" is for "hydrino". The energy spectrum would transform as $E_n/E_1 \to (n_H/n_h)\times(E_n/E_1)$ rather than $E_n/E_1 = 1/n^2 \to n^2$ as in the model of Mills. The scaling would be fractional.

3. Could this model explain why the transition to hydrino state is non-radiative? Dark photon with $h_{eff}/h = n_h < n_H$ it would have shorter wave length by factor $1/n_h$ in the range λ/n_H, $\lambda \in [10, 20]$ nm and would be observed only when transformed to ordinary photon. If the photon emitted in the transition is dark it could leak out of the system, or could be absorbed by the catalyst if the catalyst has also dark hydrogen atoms with the same value of $h_{eff}/h = n_h$. The catalyst would serve as a seed of $n_H \to n_h$ phase transitions.

4. How to understand the observed spectrum in the EUV range [10,20] nm? The transition energies for the transitions from the ground state of hydrogen atom to hydrino state would be of form

$$\frac{\Delta E}{E_1} = (\frac{n_H}{n_h})^2 - 1 \ . \tag{10.1}$$

   For the transitions between hydrino states with principal quantum numbers n_1 and n_2 one would have

$$\frac{\Delta E}{E_1} = \left[(\frac{n_H}{n_{h_2}})^2\frac{1}{n_2^2} - (\frac{n_H}{n_{h_1}})^2\frac{1}{n_1^2}\right] = n_H^2\left[(\frac{1}{n_{h_2}})^2\frac{1}{n_2^2} - (\frac{1}{n_{h_1}})^2\frac{1}{n_1^2}\right] \ . \tag{10.2}$$

   If one allows fractional values n_H/n_h, it is rather easy to explain the effective continuum spectrum. One can also consider the option that the transitions are such that n_h is a divisor of n_H and more generally n_{h_2} divides n_{h_1} in the transitions of hydrinos. If only the range of EUV energies spanning one octave is assumed, additional conditions follow.

Here one must notice that single photon transition between ground states $n = 1$ with different values of h_{eff} is not possible without spin flip for electron so that the minimum change of n for ground state transitions without spin flip is $n = 1 \to 2$. Spin flip allows also transitions $n = 1 \to 1$. The photon emitted in $n_H \to n_h$ transition would define the EUV analog of hydrogen 21 cm line.

The simplest option corresponds to $n_H = 6$.

(a) This option satisfies also the natural constraint that Bohr radius for $n_h = 2$ hydrino is larger than electron Compton length. There are also more complex options to consider (such as $n_H = 12$ and $n_H = 2^4 = 16$) but this option seems rather unique.

(b) Spin-non-flip transition $n = 1 \to 2$ has the energy $\Delta E/E_1 = 5E_1/4$ with $\Delta E/eV = 17.0$. Primary spin-flip transitions $n = 1 \to 1$ have energies $\Delta E/E_1 \in [8, 3]$ with $E/eV \in [108.8, 40.8]$. Secondary spin-flip transition has energy $\Delta E/E_1 = 5$ giving $\Delta E/eV = 60.0$. Only 17 eV transition is outside the EUV energy range considered by Mills.

(c) This would however force to modify the conjecture that the imaginary parts for the zeros of Riemann Zeta correspond to the values of $1/\alpha_K$ assigned with electroweak U(1) hypercharge at p-adic length scales correspond to p-adic primes near prime powers of two [K9]. The prediction for α_R would be $1/\alpha_R = 22.8$. The minimal critical values of $1/\alpha_K$ would become 6-ples of the imaginary parts. Hydrino would correspond to a phase with an anomalously large value of $1/\alpha_K$ with the existence of perturbation theory possible only in special situations.

The model suggests a universal catalyst action. Among other things catalyst action requires that the reacting molecule gets energy to overcome the potential barrier making reaction very slow. If an atom - say (dark) hydrogen - in catalyst suffers a phase transition to hydrino (hydrogen with smaller value of h_{eff}/h), it liberates binding energy, and if one of the reactant molecules receives it it can overcome the barrier. After the reaction the energy can be sent back and catalyst hydrino returns to the ordinary hydrogen state. The condition that the dark binding energy is above the thermal energy gives a condition on the value of $h_{eff}/h = n$ as $n \leq 32$. The size scale of the dark largest allowed dark atom would be about 100 nm, 10 times the thickness of the cell membrane.

The notion of high energy phosphate bond is somewhat mysterious concept and manifests as the ability provide energy in ATP to ADP transition. There are claims that there is no such bond. I have spent considerable amount of time to ponder this problem. Could phosphate contain (dark) hydrogen atom able to go to the hydrino state (state with smaller value of h_{eff}/h) and liberate the binding energy? Could the decay ATP to ADP produce the original possibly dark hydrogen? Metabolic energy would be needed to kick it back to ordinary bond in ATP.

One could turn the situation upside down and ask whether the cold fusion effects could correspond to the formation of hydrino atoms in the proposed sense.

(a) h_{eff} would be reduced rather than increase in the presence of a catalyst inducing a phase transition reducing $h_{eff,H}$. In particular, could the formation of string of dark nuclei with size of electron be replaced with the formation of strings of dark hydrinos with the same size but with smaller Planck constant as for ordinary hydrogen atom? This picture would be more in spirit with that proposed by Holmlid but forces to challenge the hypothesis that cold fusion followed by the decay of dark nuclei to ordinary nuclei is responsible for the anomalous energy production.

(b) Holmlid however reports evidence for superconductivity. The reduction of the value of Planck constant and thus of Compton scale of electron does not support superconductivity.

(c) Of course, both phenomena could be involved. Hydrogen with $n_H = 6$ and hydrinos with $h_{eff}/h = n_h \in \{2, 3\}$ for electrons would have dark nuclei with $h_{eff}/h = 2^{11}$. The scaled down Bohr radius for $n_h = 2$ would be 5.9×10^{-12} m and dark proton size

would be electron Compton length 2.4×10^{-12} m. For other options the Bohr radius could be smaller than the size of dark proton so that $n_H = 6$ option would be unique.

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