Cold Fusion Again

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Abstract

During years I have developed two models of cold fusion and in this article these models are combined together. The basic idea of TGD based model of cold fusion is that cold fusion occurs in two steps. First dark nuclei (large $h_{eff} = n \times h$) with much lower binding energy than ordinary nuclei are formed at magnetic flux tubes possibly carrying monopole flux. These nuclei can leak out the system along magnetic flux tubes. Under some circumstances these dark nuclei can transform to ordinary nuclei and give rise to detectable fusion products.

An essential additional condition is that the dark protons can decay to neutrons rapidly enough by exchanges of dark weak bosons effectively massless below atomic length scale. Also beta decays in which dark W boson decays to dark electron and neutrino can be considered. This allows to overcome the Coulomb wall and explains why final state nuclei are stable and the decay to ordinary nuclei does not yield only protons. Thus it seems that this model combined with the TGD variant of Widom-Larsen model could explain nicely the existing data.

In this article I will describe the steps leading to the TGD inspired model for cold fusion combining the earlier TGD variant of Widom-Larsen modelwith the model inspired by the TGD inspired model of Pollack's fourth phase of water using as input data findings from laser pulse induced cold fusion discovered by Leif Holmlid and collaborators. I consider briefly also alternative options (models assuming surface plasma polariton and heavy electron). After that I apply TGD inspired model in some cases (Pons-Fleischman effect, bubble fusion, and LeClair effect). The model explains the strange findings about cold fusion - in particular the fact that only stable nuclei are produced - and suggests that also ordinary nuclear reactions might have more fundamental description in terms of similar model.

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1 Introduction

Despite the fact that NASA is funding cold fusion research, cold fusion research is still regarded as almost criminal activity amongst people enjoying monthly salary as research professionals. The impossibility to communicate with so called respected scientists implies that cold fusion researchers do not receive healthy criticism. It is only human that cold fusion researchers tend to act reactively in this kind of situation. Defensive and reactive attitudes also imply that the research standards cannot be as high as they could be.

Cold fusion research is often carried out by companies with the goal of developing a commercial product. Funding is essential for achieving this and the reports about achievements tend to look like commercials. For an outsider it is very difficult to get information about what has been really achieved.

A serious problem is that a real theory of cold fusion is lacking and the standards of the theorizing carried out by experimenters are not too high. Fashionable pseudo-scientific notions like zero point energy (ZPE) having no mathematical justification and lacking real explanatory power plague the theorizing.

Before joining to the crowd labelling cold fusion researchers bad boys of science, one should realize that the battle for getting funding is merciless. Hot fusion research is an instutionalized branch of science but has failed to achieve its goal and there are a lot of researchers who want their funding to continue and fight desperately to prevent outsiders from entering their territory. The last 30 years of superstring hegemony is an excellent example of the same phenomenon.

Why I am writing about cold fusion? If I were standard career builder, I would of course dismiss the cold fusion research altogether since anything positive that I say about this kind of topics can be used against me. The new physics implied by TGD could however make possible phenomena explaining cold fusion and my research ethics does not allow me to make the standard choice concerning my attitudes to cold fusion. I have already earlier discussed cold fusion [K11, K7, K3, K2, L3].

This particular work was inspired by a comment to my blog article (see `http://tinyurl.com/zvqfqkt`) providing very interesting links to cold fusion related work that I was not aware of (thanks to Axil!). Reading this material led to much more precise formulation of one of the models for cold fusion that I had proposed in [L3] with inspiration coming from the model of fourth phase of water discovered by Pollack's. I also became finally convinced that cold fusion is real science.

The basic idea of TGD based model is that cold fusion occurs in two steps. First dark nuclei (large $h_{eff} = n \times h$) with much lower binding energy than ordinary nuclei are formed at magnetic flux tubes possibly carrying monopole flux. These nuclei can leak out the system along magnetic flux tubes. Under some circumstances these dark nuclei can transform to ordinary nuclei and give rise to detectable fusion products. An essential additional condition is that the dark protons can decay to neutrons rapidly enough by exchanges of dark weak bosons effectively massless below atomic length scale. Also beta decays in which dark W boson decays to dark electron and neutrino can be considered. This allows to overcome the Coulomb wall and explains why final state nuclei are stable and the decay to ordinary nuclei does not yield only protons. Thus it seems that this model combined with the TGD variant of Widom-Larsen model [K3] could explain nicely the existing data.

Before continuing it is good the sharpen the view about what the loose term *cold fusion* means as a term (see `http://coldfusionnow.org/what-is-cold-fusion/`). According to this reference:

Cold fusion describes a form of energy generated when hydrogen interacts with various metals like nickel and palladium. Cold fusion is a field of condensed matter nuclear science CMNS, and is also called low-energy nuclear reactions LENR, lattice-assisted nuclear reactions LANR, low energy nanoscale reactions LENR, among others. Cold fusion is also referred to as the Anomalous Heat Effect AHE, reflecting the fact that there is no definitive theory of the elusive reaction.

Beloved child is said to have many names but the many names does not imply being beloved!

One can find an article about cold fusion in Wikipedia (`https://en.wikipedia.org/wiki/Cold_fusion`). Although cold fusion has become legitimate science and cold fusion researchers are no more treated as criminals, the hostile tone of the article has not changed. The article even forgets to mention at all that NASA is one of the prestigious organizations studying cold fusion. This tells about the ethical and intellectual standards of the academic science nowadays.

Many non-standard mechanisms claimed to lead to nuclear fusion have been proposed and not all of them can be regarded as cold fusion. In the following I will describe the steps leading to the TGD inspired model for cold fusion combining the earlier TGD variant [K3] of Widom-Larsen model [C2] (`http://newenergytimes.com/v2/sr/WL/WLTheory.shtml`) with the model [L3] inspired by the TGD inspired model of Pollack's fourth phase of water [L1] using as input data findings from laser pulse induced cold fusion discovered by Leif Holmlid and collaborators [C3] (see popular article `http://tinyurl.com/nbephxb`). I consider briefly also alternative options (models assuming surface plasma polariton and heavy electron). After that I apply TGD inspired model in some cases (Pons-Fleischman effect, bubble fusion, and LeClair effect (see `https://nanospireinc.com/Fusion.html`)).

2 TGD Inspired Proposal For The Mechanism Of Cold Fusion

In TGD inspired model of cold fusion the basic new physics elements are following.

1. p-Adic length scale hypothesis [K13, K5] allowing to consider the possibility that given particle can exists in several phases with the p-adic prime $p \simeq 2^k$ and having mass scale proportional to $2^{-k/2}$. For instance, electron having usually $k = 127$ could exist in phase $k = 113$ assignable to atomic nuclei or even $k = 107$ assignable to hadrons.

2. Hierarchy of Planck constants $h_{eff}/h = n$ labelling the phase of dark matter with magnetic flux tubes possibly carrying monopole fluxes identified as as carriers of dark matter. Key idea is that dark protons and even dark deuteriums and even heavier nuclei can form dark variants of nuclei with appropriately scaled down binding energy. This step could be present also in the ordinary hot nuclear fusion.

The basic challenges of any model of cold fusion (LENR) are very demanding.

1. One must understand how Coulomb wall can be overcome. If LENR is in question, it seems that new physics is unavoidable.

2. The isotope ratios and also the composition of nuclei should be near to those appearing in natural environment.

3. In the original cold fusion experiments neither neutrons and gamma rays were detected and there were also other deviations from standard nuclear physics. One should also understand why the energy yield is so small and why the production rate of the nuclei is so modest.

4. There is evidence that only stable isotopes (at least stable with respect to weak decays) are produced or at least detected.

There are three basic models, which could satisfying the constraints.

1. Dark scaled up variants of weak bosons can make weak interactions as strong as em interactions below atomic scale. The transformation of protons to neutrons by exchange of dark weak boson or by dark weak decay allows to overcome Coulomb wall and explain why only nuclei stable against beta decays are produced.

2. p-Adically scaled up variant of electron considerably heavier than electron is possible and leads to the analog of muon-catalyzed fusion. This could help to overcome Coulomb wall but fails to explain how neutron containing nuclei could be obtained from dark proton sequences and why the final state nuclei seem to be stable.

3. Dark fusion could be the fundamental process and take place at magnetic flux tubes and leads to dark nuclei, which under some circumstances can transform to ordinary nuclei liberating nuclear binding energy. The leakage of the produced dark nuclei from system along magnetic flux tubes explains why the production rates of nuclei and energy are so modest and why gamma rays, neutrons and other nuclei are not detected. Also ordinary hot nuclear fusion would rely on this mechanism and the high temperature in Sun would be generated by the transformation to ordinary nuclei - perhaps in the collisions of dark nucleus beams leaking out of the system along magnetic flux tubes with dense targets. Universal abundances and isotope ratios are predicted. This model combined with the generalization of Widom-Larsen model is strongly favored.

The combination of first and third mechanisms satisfies the basic conditions if also hot fusion proceeds by this mechanism. Thus dark variants of nuclei and weak interactions would become an essential part of nuclear physics.

2.1 TGD Variant Of Widom-Larsen Model

Widom and Larsen (for articles see the Widom Larsen LENR Theory Portal [C2] (`http://newenergytimes.com/v2/sr/WL/WLTheory.shtml`) have proposed a theory of cold fusion (LENR) [C1], 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 [K7]. 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.

It is difficult to understand how this step could be fast enough and this is certainly the weak point of Widom-Larsen model. The TGD inspired solution of the problem [K3] could be that weak interactions are mediated by dark variants of weak bosons such that weak scale is scaled up to $L(k)$ by scaling with h_{eff}/h. $k = 137$ would correspond to atomic length scale and $k = 127$ to electron's p-adic length scale. The latter option is suggested by the superdense matter proposal of Holmlid. Weak bosons would behave like massless bosons below $L(k)$. This would make weak interactions as strong as electromagnetic interactions and the crucial weak interaction step could proceed swiftly.The dark variant of weak interactions would apply below $L(k)$ and make weak gauge bosons effectively massless below $L(k)$ characterizing the flux tube (electronic p-adic length scale in the model considered). Only exchanges of W bosons and dark beta decays (if possible) make this happen fast: ordinary beta decays would be as slow as in standard model since W bosons would be massive above $L(k)$.

This makes possible the exchange of effectively massless dark W bosons between dark protons at flux tube and dark nuclei at second flux tube. This exchange allows to get rid of Coulomb wall by transforming proton to neutrons and the formation of dark nuclei can proceed. Exchange of dark W bosons also leads to a rapid decay of dark nuclei to nuclei stable with respect to weak interactions: observed final state nuclei are indeed stable. Dark beta decay makes possible simpler transformation to beta-stable dark nuclei.

2.2 Could TGD Allow Heavy Electron As Exotic State Of Electron?

There exists evidence that neutrino mass scale can vary. TGD explanation is that the p-adic mass scale associated characterized by $p \simeq 2^k$, can vary. There would be several values of k and the value of k would depend on the environment of neutrino. resides.

This allows to play with the possibility large effective mass of electron used routinely in condensed matter models in some situations corresponds to a real mass. The p-adic mass scale $L(k) \propto 2^{k/2}$ assignable to Mersenne prime $p = M_{127} = 2^{127} - 1$ with $k = 127$ characterizing electron would be reduced from that associated with $k = 127$ to some smaller value of k. One possibility is the scale $L(k = 113)$ associated the Gaussian Mersenne $p = M_{G,113} = (1 + i)^{113} - 1$ characterizing the size scale of atomic nuclei. Second possibility is the Mersenne prime $2^{107}-1$ characterizing nucleons so that electron mass is scaled up by $2^{(127-k)/2}$. For $k = 127 \rightarrow k = 107$, mass (size) would be scaled up (down) by a factor $2^{10} = 1024$ ($2^{-10} = 1/1024$). For $k = 127 \rightarrow k = 113$, mass (size) would be scaled up (down) by a factor $2^7 = 128$ ($2^{-7} = 1/128$).

This option can be considered as a manner to overcome Coulomb wall but it does not explain why only stable nuclei are produced in cold fusion.

2.3 Cold Fusion Of Dark Protons To Dark Nuclei At Dark Magnetic Flux Tubes Followed By Transformation To Ordinary Nuclei

The TGD inspired quantum model for living matter in terms of magnetic flux tubes (magnetic bodies) carrying dark matter as large h_{eff} phases leads to the model of dark cold fusion suggesting in turn a model for cold fusion [L3].

1. Pollack's exclusion zones (EZs) [L1] are negatively charged regions of water giving rise to what Pollack calls the fourth phase of water. In TGD inspired model [K8, K9, K2] [L1] it is assumed that water molecules form inside EZs a phase with effective stoichiometry $H_{1.5}O$ with each hydrogen bonded pair of water molecules losing one proton, which becomes dark proton at magnetic flux tube. The dark protons can form string like objects at flux tubes identifiable as dark nuclei. The simplest assumption is that the binding energy of dark nuclei scales as $1/h_{eff}$ and would be much lower than ordinary nuclear binding energy. In biological applications it has been assumed that this energy is in the range of bio-photon energies covering visible and UV energies. The distance between dark protons would be about 1 nm.

   Dark nuclear binding energy would be liberated in the formation of dark nuclei and the emitted dark photons with energy of order O-H bond energy about 5 eV would kick protons from further water molecules. Dark cold fusion would proceed as a chain reaction much like the ordinary fusion. This could happen also for dark variants of deuterons since deuterons could be regarded as elementary particle like entities corresponding to p-adic prime $k = 109$ whereas protons would correspond to $k = 107$. Even nuclei could appear as building bricks of nuclei made from nuclei. Mathematician would unashamedly generalize this to a fractal hierarchy of nuclei formed from nuclei formed from...

2. Could dark nuclei transform to ordinary ones? If they do so, large energies in the range 1-7 MeV per nucleon are liberated and the system ends up to a high temperature. This could make possible ordinary nuclear fusion and I have proposed that biofusion - for which evidence exists - is preceded by dark cold fusion [L3].

   One can wonder whether also the ordinary fusion involves dark cold fusionas as the first step. Or could all nuclei be produced via dark fusion of protons to light dark nuclei, which in turn coud fuse to heavier dark nuclei followed by beta decays and whether the distributions of elements are determined already at this level? High temperature could be seen as a consequence of the transformation of dark nuclei to ordinary nuclei rather than a prerequisite of hot fusion. This would predict universal composition present also in natural environment and suggested by the cold fusion experiments.

3. The mechanism leading to cold fusion would be very general. Charge separation in which protons are transformed to dark protons at magnetic flux tubes would be enough. This could

take be achieved by irradiation by visible or IR light as in Pollack's experiments. Oscillating water bubble, cavitation, laser pulses inducing Coulomb explosion, and strong electric fields used in electrolysis could induce charge separation and dark fusion inducing ordinary fusion might take place in all these situations.

This kind of charge separation occurs also in rotating magnetic systems as was observed already by Faraday and these systems indeed exhibit free energy anomalies not easy to understand in standard physics. The space-energy generator of Tewari [H1] is an example of this kind of system [L4] [K1]. The rotating F_0 machine analogous to the generator of electric power plant and transforming ADP to ATP in mitochondria might use dark nuclear fusion as power source in some situations and could be behind the reported biofusion. The transformation of large $h_{eff}/h \sim 10^6$ dark nuclei with size of about 10 nm to ordinary nuclei could be of course quite too slow.

2.4 Fusion Induced By Coulomb Explosions As A Manner To Fix The Details Of TGD Inspired Model

Leif Holmlid has introduced the notion of fusion induced by Coulomb explosion of ultradense deuterium (see popular article http://tinyurl.com/nbephxb). The slides of the talk by Sweinn Olaffsson (see http://tempid.altervista.org/SRI.pdf) give a more technical representation about the subject. Also ultradense variant of hydrogen can be considered. The article *Laser-driven nuclear fusion D+D in ultra-dense deuterium: MeV particles formed without ignition* (see http://tinyurl.com/pm56kk3) gives a more detailed representation about the idea [C3].

The abstract of article provides a summary of the idea.

The short D-D distance of 2.3 pm in the condensed material ultra-dense deuterium means that it is possible that only a small disturbance is required to give D+D fusion. This disturbance could be an intense laser pulse. The high excess kinetic energy of several hundred eV given to the deuterons by laser induced Coulomb explosions in the material increases the probability of spontaneous fusion without the need for a high plasma temperature. The temperature calculated from the normal kinetic energy of the deuterons of 630 eV from the Coulomb explosions is 7 MK, maybe a factor of 10 lower than required for ignition. We now report on experiments where several types of high-energy particles from laser impact on ultra-dense deuterium are detected by plastic scintillators. Fast particles with energy up to 2 MeV are detected at a time-of-flight as short as 60 ns, while neutrons are detected at 50 ns time-of-flight after passage through a steel plate. A strong signal peaking at 22.6 keV u1 is interpreted as due to mainly T retarded by collisions with H atoms in the surrounding cloud of dense atomic hydrogen.

What is important that fusion products assignable to Coulomb explosions have been indeed observed. Also kaons, pion, muons, and their decay products have been detected. It is amusing that Coulomb explosion could occur in the explosive reaction of alkali metals with water familiar from school days (see https://www.youtube.com/watch?v=jLNpQqikvKY).

One can of course challenge the notion of superdense hydrogen/deuterium.

1. The kinetic temperature assignable to the average kinetic energy of 630 eV of deuterium atoms resulting in Coulomb explosion is about one order of magnitude lower than the temperature $T = 10^7$ K $\simeq$ 1 keV in the solar core and one can argue that ordinary fusion is impossible. Even the solar fusion proceeds very slowly.

2. Laser beam is assumed to generate ultradense deuterium with density which is about million times higher than the density of normal deuterium phase. The distance between deuterium atoms would be 2.3 pm and about 100 times shorter than than the distance between ordinary deuterium atoms (which should be 2.3 Angstroms). Charge separation occurs since the electric field of laser beam strips of electrons and the highly charged superdense deuterium explodes and produces very energetic deuterium ions. The average energy is measured to be about 630 eV and equating this energy with the repulsing Coulomb interaction energy of deuteron atoms one obtains the estimate for the distance between deuteron atoms. The Coulombic energy generated by the compression should come from the laser pulse.

TGD suggests a one-dimensional variant of this model in which the compression occurs only in the direction of laser beam and generates a string of dark deuterium nuclei at magnetic flux tube. Deuterium nuclei themselves would be unchanged: only their Compton lengths scale up by $h_{eff}/h = 2^{10}$ and they would form dark analogs of ordinary nuclear strings formed from D-D units. Similar model applies to dark proton strings.

1. The momentum given by the laser pulse to the nuclei forces compression in the normal direction and for large enough compression a new phase consisting of dark nucleons at magnetic flux tubes parallel to the laser beam is formed. For this phase large Coulomb energy would be compensated by scaled up variant of nuclear binding energy if it behaves like $1/h_{eff}$. The scaling of the p-adic length scale $L(107)$ of nucleon to effective p-adic length scale $L(127)$ is an attractive guess gives a scaling by factor 10^3 in normal direction. Nuclear binding energy scale 1 MeV scales down to of 1 keV. By the effective 1-dimensionality density would increase by factor 10^3 rather than 10^6 as assumed by Holmlid and collaborators [C3].

2. What is remarkable that in Sun the nuclear fusion takes place at temperature of 1.5 keV although the rate is extremely slow. This is thought to be made possible by tunnelling. The notion of tunneling in potential is of course an effective description based on the use of non-relativistic potential model treating nuclei as point-like objects. TGD suggests that tunneling should be replaced by two steps. In the first a phase transition forming dark nuclei with $h_{eff}/h = 2^{10}$ and nuclear size $L(k = 127) \simeq 2.5$ pm rather near to the claimed D-D distance 2.3 pm. At the second step a phase transition to ordinary nucleons with standard value of $h_{eff}/h = 1$ or to ordinary bound state of nucleons would occur as the counterpart of tunnelling.

3. Dark nuclear binding energy should not only compensate the dark Coulomb energy but also liberate energy contributing to the kinetic energy of nuclei produced in Coulomb explosion. Coulomb explosion involves both the decay to back ordinary nucleons and nuclear strings representing heavier nuclei [K7]. This process would liberate energy of order nuclear binding energy per nucleon: for nuclei heavier than D this is around 7 MeV. The energy gain would be much higher than in hot fusion.

4. One can estimate the lower bound for the Coulomb interaction energy in the first approximation as sum of interaction energies with the nearest neighbors divided by two. For flux dark proton strings along flux tube parallel to laser beam one would have 2 neighbours. This would give $E_c > \alpha\hbar/r$. Distance of $L(137) = 1/1.28$ Angstrom corresponds to Coulomb energy $E_c = \alpha(\hbar/r)$, giving $E_c > 92$ eV.

   For $k = 127$ (electron's p-adic length scale) instead of $k = 137$ Coulomb energy would be by a factor 32 higher and the lower bound for Coulomb energy is about $E_c = 3$ keV which happens to correspond to the temperature in solar core. Taking into account the interactions with all neighbors along the nuclear flux tube gives coefficient $x = (1 + 1/2 + 1/3 + ...)$. There is some maximal value of deuterium nuclei for which the Coulombic energy can be compensated by scaled up nuclear binding energy per nucleon. For dark alpha particle one has $x = 1$. The value of 6.3 keV of average kinetic energy is higher than the estimate for Coulomb energy and suggests that liberated dark nuclear binding energy contributes to the kinetic energy of deuteron atoms in the final state.

   For Helium formed as D-D composite the average binding energy per nucleon is 7 MeV scaling down to 7 keV. Hence the Coulomb energy is more than compensated by nuclear binding energy for dark $k = 127$ D-D but for heavier nuclei nuclear binding energy wins Coulombic interaction energy. In solar interior the temperature is about 1.5 keV and the reactions so slow that hot fusion at these temperatures is not practical at Earth (see `https://en.wikipedia.org/wiki/Nuclear_fusion`). The formation of dark nuclei could increase the fusion rate since the reactants would spend a longer time near each other.

   Coulomb potential transforms from infinite high potential to triangular potential in 1-D case and nucleon size is of order of their mutual distance during this period. This could favor the occurrence of reactions at quark level. In D-D dark cold fusion only decomposable to ordinary deuteron nuclei and having Z=N are formed and beta decays can lead to other nuclei. Since deuteron is stable, this could allow to understand why neutrons are not observed in the experiments. A more convincing explanation is that they are dark and leak out from the system along dark magnetic flux tubes.

The nuclei formed by fusing dark variants deuterium nuclei are very special and cold fusion experiments suggests that all nuclei an be produced. Hence on must consider also the formation of dark nuclei for which the initial state consists of a sequence of dark protons: this nuclear string can decay only to ordinary protons unless some protons can be transformed to neutrons in fast enough manner. Ordinary weak interactions are too slow to allow this.

1. For deuterium the average binding energy per nucleon is 1 MeV scaling down to 1 keV assuming $1/h_{eff}$ scaling so that the total binding energy is 2 keV. The estimate for Coulomb energy is 3 keV and higher than the total binding energy of dark deuteron. Therefore it seems that the basic step in dark fusion is impossible! For higher nuclei however the binding energy wins unless the proton string is not too long (Coulomb energy depends non-linearly on the number of strings). Dark proton string would however decay to protons rather than ordinary nuclei containing always neutrons. Same must be true for dark nuclei.

   The problem is that ordinary weak interactions are too slow to transform dark nuclei to ordinary ones by beta decays or W exchanges with neutron containing nuclei possibly at other strings consisting of nuclei or with neutron strings.

2. The only solution of the problem is based on the combination of the model with the TGD variant of Widom-Larsen modeling in which dark W exchange or dark beta decay allows to transform incoming proton to neutron to overcome Coulomb wall. The model assumes that weak bosons are dark and therefore effectively massless below p-adic length scale $L(r \equiv 2k + 89) = (h_{eff}/h)L(89)$, $h_{eff} = 2^k$, where p-adic length scale $L(r)$ must be equal or longer than atomic length scale $L(k = 137)$. Weak exchanges would proceed as fast as electromagnetic interactions below $L(r)$. For $r = 137$ corresponding to atomic length scale this requires $h_{eff}/h = 2^{137-89)/2} = 2^{24} \simeq 1.6 \times 10^7$. For $r = 127$ corresponding to electron's p-adic length scales predicting the density of dark protons to be roughly the density reported by Holmlid one would have $h_{eff}/h = 2^{127-89)/2} = 2^{19} \simeq .5 \times 10^6$.

   Dark weak boson exchanges and dark beta decays occur fast and allow to transform protons to neutrons and vice versa by weak boson exchange between proton of protonic dark nuclear string with dark nuclear string consisting of nuclei containing neutrons. Dark nuclei would also decay rapidly to nuclei stable with respect to weak interactions. The selection rules for the formation of stable nuclei would be simple. If the dark nucleus candidate contains two neighboring protons they cannot belong to the same final state nucleus. This implies that the neutron number of finals state nuclei tends to be large than proton number and that stable nuclear strings tend to consist of neutron sequences with single proton between them. This selection rule specifies the decay products of given given dark nucleon sequence.

   A variant of this picture is inspired by the model for both ordinary and dark nuclear strings, which assumes that they consist of nucleons connected by color bonds having quark and antiquark at their ends [K7]. Four different quark pairs with em charges +1 ($u\overline{d}$, -1 ($\overline{u}d$), and 0 ($u\overline{d}$ and $d\overline{d}$) are possible. The beta decay of quark at the end of color bond reducing the charge by one unit $u \rightarrow d+W^+$ or $\overline{d} \rightarrow d\overline{u}$ reduces the charge of dark proton sequence by one unit and effectively corresponds to the ordinary weak decay $p \rightarrow n$. The dark weak boson W^+ can decay to dark pair $e^+\nu_e$ which then transforms to ordinary $e^+\nu_e$ pair: the time scale of this transformation does not matter. The final state nucleus would have proton number larger than its charge. Also some ordinary nuclei could be like this. This kind of decays anomalous from the point of view of ordinary nuclear physics has been recently observed for ordinary nuclei [C4] (see also `http://tinyurl.com/jaqrmdx`). The neutrino energies are around 5 MeV. For TGD inspired model see [L6].

   There is experimental support for this picture. In heavy electron induced fusion performed ib NASA (see `http://tinyurl.com/6qku783`) the system was bombarded with neutrons. This made possible to achieve production of stable nuclei. The interpretation is that the exchange of dark W bosons with added neutrons allowed to transform dark protons to dark neutrons by dark weak exchanges and dark beta decays to overcome the Coulomb wall and achieve beta stability.

3. There is an interesting connection with biology. I have proposed dark variants of weak interactions as an explanation for the large parity breaking effects in living matter implying

chiral selection of biomolecules, and the proposed mechanism makes the model quantitative. Indeed, DNA would be accompanied by dark proton sequences with dark proton size of order 1 nm. The amazing observation made years ago was that the states of dark nucleons are in 1-1 correspondence with the DNA, RNA, amino-acids, and tRNA and realize genetic code at the level of dark nuclei [K7, K4]. In this framework it would seem that genes could correspond to dark nuclear strings consisting of neutron sequences having single proton between them. If two dark protons follow each other the gene ends or begins.

The rate for the phase transition to ordinary nuclei is an important factor.

1. If this rate is low, dark nuclei could escape the system along dark magnetic flux tubes and the reaction yield would be small as also the energy yield. One might hope that the attachment of the dark magnetic flux tubes to some target could lead to collisions with ordinary nuclei inducing the decay of dark nuclei to ordinary nuclei.

2. Gamma rays produced in ordinary nuclear fusion would be replaced by dark X rays with energies in few keV range produced in dark nuclear reactions and could leak out of the system along the dark magnetic flux tubes and remain undetected. In the phase transition transforming dark nuclei to ordinary nuclei ordinary gamma rays or bunches of dark X rays could be produced. The fact that the observed gamma ray yield is small suggests that if dark nuclei decay rapidly to ordinary ones, the emission of bunches of dark X rays dominates in this process.

2.5 Phase transition temperatures of 405-725 K in superfluid ultra-dense hydrogen clusters on metal surfaces

I received very helpful comment to my blog posting telling about the work of Prof. Leif Holmlid related to cold fusion [C3] (the relation of TGD based model of cold fusion to Holmlid's work is discussed in this chapter and also in the article [L2]). The basis idea of Holmlid is that cold fusion is preceided by a formation of ultradense protonium or deuterium matter for which distance between protons/deuterium nuclei is about 2.3 pm, which is of the same order of magnitude electron Compton length 2.42 pm.

This helped to find a new article of Holmlid and Kotzias with title "Phase transition temperatures of 405-725 K in superfluid ultra-dense hydrogen clusters on metal surfaces" published towards the end of April [C14] (see `http://tinyurl.com/hxbvfc7`). The article provides very valuable information about the superdense phase of hydrogen/deuterium that he postulates to be crucial for cold fusion.

The postulated supra dense phase would have properties surprisingly similar to the phase postulated to be formed by dark magnetic flux tubes carrying dark proton sequences generating dark beta stable nuclei by dark weak interactions. My original intuition was that this phase is not superdense but has a density nearer to ordinary condensed matter density. The density however depends on the value of Planck constant and with Planck constant of order $m_p/m_{\simeq}2^{11} = 2000$ times the ordinary one one obtains the density reported by Holmlid so that the models become surprisingly similar. The earlier representation were mostly based on the assumption that the distance between dark protons is in Angstrom range rather than picometer range and thus by a factor 32 longer. The modification of the model is straightforward: one prediction is that radiation with energy scale of $1-10$ keV should accompany the formation of dark nuclei.

In fact, there are also similarities about which I did not know of!

1. The article tells that the structures formed from hydrogen/deuterium atoms are linear string like structures: this was completely new to me. The support comes from the detection of what is interpreted as decay products of these structures resulting in fragmentation in the central regions of these structures. What is detected is the time-of-flight distribution for the fragments. In TGD inspired model magnetic flux tubes carrying dark proton/D sequences giving rise to dark nuclei are also linear structures.

2. The reported superfluid (superconductor) property and the detection of Meissner effect for the structures were also big news to me and conforms with TGD picture allowing dark

suppraphases at flux tubes. Superfluid/superconductor property requires that protons form Cooper pairs. The proposal of Holmlid and Kotzias that Cooper pairs are pairs of protons orthogonal to the string like structure corresponds to the model of high Tc superconductivity in TGD inspired model of quantum biology assuming a pair of flux tubes with tubes containing the members of the Cooper pairs. High Tc would be due to the non-standard value of $h_{eff} = n \times h$. This finding would be a rather direct experimental proof for the basic assumption of TGD inspired quantum biology [K8, K9].

3. In TGD model it is assumed that the density of protons at dark magnetic flux tube is determined by the value of h_{eff}. Also ordinary nuclei are identified as nuclear strings [K7] and the density of protons would be the linear density protons for ordinary nuclear strings scaled down by the inverse of h_{eff} - that is by factor $h/h_{eff} = 1/n$.

   If one assumes that single proton in ordinary nuclear string occupies length given by proton Compton length equal to (m_e/m_p) time proton Compton length and if the volume occupied by dark proton is 2.3 pm very nearly equal to electron Compton length 2.4 pm in the ultra-dense phase of Holmlid, the value of n must be rather near $n \simeq m_p/m_e \simeq 2^{11} \simeq 2000$ as the ratio of Compton lengths of electron and proton. The physical interpretation would be that the p-adic length scale of proton is scaled up to essentially that of electron which from p-adic mass calculations corresponds to p-adic prime $M_{127} = 2^{127} - 1$ [K5]. The ultra dense phase of Holmlid would correspond to dark nuclei with $h_{eff}/h \simeq 2^{11}$.

   My earlier intuition was that the density is of the order of the ordinary condensed matter density. If the nuclear binding energy scales as $1/h_{eff}$ (scaling like Coulomb interaction energy) as assumed in the TGD model, the nuclear binding energy per nucleon would scale down from about 7 MeV to about 3.5 keV for $k = 127$. This energy scale is same as that for Coulomb interaction energy for distance of 2.3 pm in Holmlid's model (about 5 keV). It must be emphasized that larger values of h_{eff} are possible in TGD framework and indeed suggested by TGD inspired quantum biology. Amusingly, my original too restricted hypothesis was that the values of n comes as powers of 2^{11}.

4. In TGD based model scaled down dark nuclear binding energy would (more than) compensate for the Coulomb repulsion and laser pulse would induce the phase transition increasing the density of protons and increasing also Planck constant making protons dark and leading from the state of free protons to that consisting of dark purely protonic nuclei in turn transforming by dark weak interactions to beta stable nuclei and finally to ordinary nuclei liberating essentially ordinary nuclear binding energy. In TGD based model the phase transition would give rise to charge separation and the transition would be highly analogous to that occurring in Pollack's experiments [L1] [L1].

It seems that the model of Holmlid and TGD based model are very similar and Holmlid's experimental findings support the vision about hierarchy of dark matter as phases of the ordinary matter labelled by the value of $h_{eff}/h = n$. There are also other anomalies that might find explanation in terms of dark nuclei with $n \simeq 2^{11}$. The X rays from Sun have been found to induce a yearly variation of nuclear decay rates correlating with the distance of Earth from Sun [C6, C13, C9].

1. One possible TGD based explanation relies the nuclear string model [K7]. Nucleons are assumed to be connected by color flux tubes, which are usually neutral but can be also charged. For instance, proton plus negative charged flux tube connecting it to the neighboring nucleon behaves effectively as neutron. This predicts exotic nuclei with the same chemical properties as ordinary nuclei but with possibly different statistics. X rays from Sun could induce transitions between ordinary and exotic nuclei affecting the measured nuclear reaction rates which are averages of all states of nuclei. A scaled down variant of gamma ray spectroscopy of ordinary nuclei would provide an experimental proof of TGD based model.

2. The fact that the energy scale is around 3 keV suggests that X rays could generate transitions of dark nuclei. If so, the transformations of dark nuclei to ordinary ones would affect the measured nuclear transition rates. There are also other anomalies such as those reported by Rolfs et al [C7, C8], which might find explanation in terms of presence of dark variants of nuclei ordinary nuclei.

2.6 Do All Variants Of Cold Fusion Reduce To Dark Bubble Fusion?

During years I have many times tried to understand what happens in electrolysis and every time I have been forced to to admit that I do not! Very embarrassing observation. I have tried to gain wisdom from an old chemistry book with 1000 pages again and again but always in vain. This is especially embarrassing because a unified theory builder to be taken seriously is expected to build brave new brane worlds in 11 or 12 dimensions to possibly explain a possible detected particle at mass 750 GeV at LHC instead of trying to understand age old little problems solved aeons ago. The wau-coefficient of chemistry is zero as compared to the awesome 10^{500} of M-theory.

Energetics has been my personal problem (besides funding). I learn from chemistry book that an electric field - say voltage of 2 V per 1 mm splits molecules to ions. The bond energies of molecules are in few eV range. For instance, O-H bond has 5 eV energy. $V = 2\text{V/mm}$ electric field corresponds to electrostatic energy $E = eVd \sim 2^{-10}$ eV energy gain for a unit charge moving from the end of the bond to the other one. This is incredibly small energy and to my understanding should have absolutely no effect to the state molecule. Except that it has!

A heretic thought: could it be that chemists have just accepted this fact (very reasonable!) and built their models as mathematical parameterizations without any attempt to understand what really happens? Could the infinite vanity of theoretical physicists have prevented them from lowering themselves to the intellectual level of chemists and prevented them from seeing that electrolysis is not at all understood?

In order that this kind of energy would have so drastic effect as splitting molecule to pieces, the system molecule + yet unidentified "something" must be in critical state. Something at the top of hill so that even slightest perturbation makes it fall down. The technical term is criticality or even quantum criticality.

1. Biological systems are critical systems extremely sensitive to small changes. Criticality means criticality against molecular ionization - charge separation basically. Also in electrolysis this criticality is present. Both DNA and cell are negatively charged. Inside cells there are various kinds of ions. In TGD Universe all matter is quantum critical.

2. Charge separation occurs also in Pollack's experiments [L1] in which the fourth phase of water is generated. This phase contains negatively charged regions with effective $H_{1.5}O$ stoichiometry (hydrogen bonded state of two water molecules which has lost proton). Positive charge associated with lost protons has gone outside these regions.

What produces quantum criticality against charge separation? What is this unidentified "something" besides the system? Magnetic body carrying dark matter! This is the answer in TGD Universe. The TGD inspired model [L3] assumes that the protons transform to dark protons at dark magnetic flux tubes possibly carrying monopole flux. If these protons form dark nuclei the liberated dark nuclear energy can split further O-H bonds and transform protons to dark phase. The energy needed is about 5 eV and is in the nuclear binding energy scale scaling as $1/h_{eff}$ (like distance) if the size scale of dark protons proportional to h_{eff}/h is 1 nm. One would have $h_{eff}/h \simeq 10^6$: the size scale of DNA codons - not an accident in TGD Universe [K7, K4]. The liberated dark nuclear energy can ionize other molecules such as KOH, NaOH, HCl, Ca(OH)^2, CaO,... Entire spectrum of values of h_{eff}/h is possible. For laser pulse induced fusion assumed to induce longitudinal compression one would have $h_{eff}/h \simeq 10^3$. Dark nuclear physics with non-standard values of Planck constant would be a crucial element of electrolysis. Condensed matter physics and nuclear physics would not live in totally separate compartments and dark matter an ordinary matter would interact! How humiliating for theoreticians! I do not hear the derisive laughter of superstring theoreticians anymore!

Ordinary electrolysis would thus produce dark nuclei. The problem is that most of them would leak out from the system along dark flux tubes and potentially available nuclear energy is lost! As also various elements so badly needed by modern techno-society! For instance, in the splitting of water to hydrogen, the flux tubes assignable to the beam containing hydrogen would take the dark nuclei away. Could one transform dark nuclei to ordinary ones?

1. If this beam collides with say metal target, some fraction of the dark nuclei could however transform to ordinary nuclei and liberate really huge energy: the difference between nuclear

binding energies of initial and finals state would be essentially that of the final state unlike in ordinary nuclear fusion.

2. In particular, electrodes could induce transformation of the dark nuclei to ordinary ones. Even in the experiments of Pons and Fleichman [C11] the role of porous Pd target could be secondary: it would be only a target allowing the dark nuclei produced by bubble fusion to transform to ordinary nuclei and the large surface area would help in this respect. Same applies to Rossi's E-Cat [C12].

3. So called Brown's gas (see `https://en.wikipedia.org/wiki/Oxyhydrogen`) generated in the splitting of water is claimed to be able to melt metals although its temperature is relatively low- around 100 Celsius. The claims is of course taken not seriously by a "serious" scientists as the Wikipedia article so clearly demonstrates. It could be however understood if the melting is caused the transformation of dark nuclei to ordinary ones. The corrosion of the metallic surface in the presence of cavitating water would be also due to the dark nuclear energy. Not all of the energy would be used to produce corrosive effects, and I have in some discussions been told that in electric plants an anomalous production of energy assignable to corrosive effects in turbine has been observed. Electric plants could have served secretly as dark nuclear plants! Unfortunately, I do not have reference to this claim. LeClair effect to be discussed later affects aluminium disks inside cavitating water corrosively: LeClair might have reinvented Brown's gas!

   But why metals? The surface of metal in external electric field carries negative charge density of conduction electrons. Could it be that they attract the positively charged dark nuclei from the magnetic flux tubes back to the visible world, and help them to tranform back to ordinary nuclei? Conductors in electric fields would thus help to transform dark nuclei to ordinary matter.

4. Brown's gas is reported to have no effect on living matter? Why? If living matter uses dark nuclear physics as a basic tool, it should have developed tools to avoid the transformation of dark nuclei to ordinary nuclei in uncontrollable manner. What aspect of quantum biophysics could make this possible? Negentropy Maximization Principle [K6] defining the basic variational principle of TGD inspired theory of consciousness could be the general reason preventing this transformation [L3]. The negentropy characterizing negentropic entanglement serving as a measure for potentially conscious information assignable to non-standard values of h_{eff} would be reduced if h_{eff} is reduced. But how to understand this at a more detailed level? Could the fact that bio-molecules are mostly insulators rather than electronic conductors explain this?

One can imagine also an alternative and simpler mechanism transforming dark nuclei to ordinary ones. The dark nuclei are attracted from magnetic flux tubes to the negatively charged EZ from the magnetic flux tube and transform to ordinary nuclei. The bubbles in the electrolyte near the catode would serve as seats of the dark nuclei and flux tubes could entere to the negatively charged catode. The large surface area of Pd would make it as ideal target for the ends of the magnetic flux tubes.

2.7 Surface Plasmon Polaritons And Cold Fusion

It has been proposed that so called surface plasmon polaritons (SPPs, see `https://en.wikipedia.org/wiki/Surface_plasmon_polariton`) are important for cold fusion. In TGD framework the question is whether they are important for dark nuclear fusion or for the transformation of dark nuclei to ordinary ones.

1. SPPs involve localized surface plasmons - electron waves localized near the interface of two phases (now surface of pores of Pd target) - accompanied by polaritons, which are electromagnetic waves concentrated near the interface surface. The density of electrons varies periodically in the direction of the propagating wave. At low frequencies the dispersion relation is the linear dispersion relation for photons with light velocity determined by di-electric

constant whose real part changes sign at the surface between two phases. At large wave vectors dispersion relation approaches to

$$\omega = \frac{\omega_P}{\sqrt{\epsilon_1+\epsilon_2}} \quad , \quad \omega_P = \sqrt{n_e e^2/m_{eff}} \tag{2.1}$$

ω_P is the bulk plasma frequency for $\epsilon = 1$ characterizing also 3-D plasma waves. The wave vector dependent part coming from large wave vectors in the dispersion relation is inversely proportional to the effective mass of electron, and it it is large the frequency is essentially constant and the time dependence and spatial dependence separate into a product and no propagation happens. The wave consists of constant rapidly spatially varying part and slowly spatially varying part for which frequencies are not constant.

2. SPPs could either help formation of dark nuclei at Pd surface or their transformation to ordinary nuclei. It is difficult to see how SPPs could help to compress Pd nuclei to much denser Pd strings at flux tubes: bubble collapse and formation of EZs would allow to achieve this. Dark weak physics allows to overcome Coulomb wall and to explain why only stable final state nuclei are produced so that SPPs are not promising candidates for dark fusion.

3. If bubble fusion is responsible for the production of dark nuclei, SPPs at Pd surface could facilitate the transformation of dark nuclei arriving at them along flux tubes to ordinary nuclei. Pd is a conductor and generates in electric field electronic surface charge density, whose sign is determined by the sign of the normal component of the field. Polariton would provide the electric field. SPP is a wave involving both electric field and electric charge density induced by it on the surface of Pd target and varying periodically along the Pd surface and making it locally positively or negatively charged. Strong negative charge density could draw the positively charged dark nuclei from magnetic flux tubes and in this manner transform them to ordinary nuclei.

2.8 Heavy Electron Induced Cold Fusion Is Not Promising In TGD Framework

Muon-catalyzed fusion (`https://en.wikipedia.org/wiki/Muon-catalyzed_fusion`) was predicted by A Sakharov and F. C. Frank before 1950. L. Alvarez et al observed observed muon-catalyze fusion. Muon-catalyzed fusion takes place at temperatures considerably lower than needed for ordinary fusion. The isotope ratios are same as for hot fusion since muonium atoms acting as analogs of hydrogen atoms act as catalysts only. For instance, in muon-catalyzed D-T fusion muonium and D, and T nuclei form a D-muonium-T molecule, whose size is smaller than the size of D-H-T molecule by a factor $m_e/m_\mu \simeq 1/207$ of electron and muon masses. This makes the Coulomb wall narrower and tunneling makes it easier to achieve nuclear fusion. Unfortunately, muon-catalyzed fusion is not of practical value. Muons are not stable and and must be produced and muons get stuck to the outgoing nucleus produced in nuclear fusion.

Heavy electron catalyzed fusion can be seen as a variant of muon-catalyzed fusion. In condensed matter physics one introduces the notion of effective electron mass, which can be considerably larger than the mass of free electron and one speaks of heavy electrons (see `http://tinyurl.com/j5vnvqu`). The mass can become even thousand times larger than electron mass. This effective mass allows a phenomenological description of the effects of the condensed matter environment on electron's interactions. If effective mass is large, the interactions with lattice make the response of the electron to external forces slower.

If it makes sense to speak of atoms formed from nuclei and heavy electrons, it might be possible to speak also about the heavy analog of hydrogen atom H_{heavy}. In this case interactions with lattice would make the response of heavy electron to the Coulomb force of nucleus slower. The size of this heavy analog of hydrogen atom, call it H_{heavy} would be proportional to $m_{e,heavy}$. For $m_e/m_{e,heavy} = 10^3$ the size of the H_{heavy} would be about 10^{-14} meters, the size scale of nucleus. The small size would make Coulomb wall between exotic atoms of this kind narrower and make cold fusion easier. One can also consider the analog of D-H_{heavy}-T molecule and the analog of muon-catalyzed fusion. I am not enough condensed matter physicist to tell whether this idea is realistic. Certainly the role of the condensed matter environment would be crucial for the process.

Around 2012 NASA published a video (see `http://tinyurl.com/6qku783`). It was told that NASA has applied patent for a method producing heavy electrons. Zawodny, who works as senior researcher tells that it has demonstrated ability to produce excess amounts of energy cleanly without hazardous ionizing radiation without producing nasty waste. In the video Zawodny stated that NASAs method for enhancement of surface plasmon polaritons (SPPs) (see `https://en.wikipedia.org/wiki/Surface_plasmon_polariton`) to initiate and sustain LENR releases energy by adding neutrons. When enough neutrons are added they spontaneously decay into something of the same mass but another element.

No details were revealed but the announcement suggest that the mechanism assumed to make possible LENR is based on this mechanism. As already explained, the role of SPPs would be same as in muon-catalyzed fusion. If the effective mass of electrons is high enough this could make possible heavy electron catalyzed fusion by creating analogs of atoms with small size forcing the deuterium nuclei nearer to each other and making possible formation of dark deuterium strings.

In TGD framework this mechanism could be also realized if it is possible to change the p-adic length scale of electron and if the heavy electron is stable enough. This option however fails to explain why the produced final state nuclei are stable and how some protons of dark proton sequence would transform to neutrons. One can wonder about the role neutrons in the experiment. In the model based on dark weak physics their role is easy to understand.

3 Examples About Cold Fusion Like Processes

In the following examples of claimed cold fusion like processes are discussed in TGD framework. The discussion of fusion induced by Coulomb explosions allowed to identify the most plausible TGD inspired model of cold fusion. The model assumes the formation of dark nuclei with $h_{eff}/h = 2^9$ scaling nucleon size scale from $L(107)$ to the length scale $L(127) = 2^{10}L(107)$ of electron and temperature scale $T \sim 1$ keV near to the temperature 1.5 keV prevailing in Sun with dark weak bosons in atomic length scale allowing to transform protons to neutrons to overcome the Coulomb wall to build dark nuclei. Second possibility would be nuclear length scale $L(113)$ involving $h_{eff}/h = 2^3$ giving temperature $T = 128$ keV making possible hot fusion in earthly conditions requiring temperature in the range $10 - 10^2$ keV. All these scales correspond to Mersenne primes or Gaussian Mersennes assigned to charged leptons, hadron physics, and nuclear physics. Weak bosons are assumed to be dark and massless below atomic length scale $L(137)$ or longer p-adic length scale and are essential for getting neutron containing final state nuclei and to explain why only stable final state nuclei are produced.

3.1 Pons-Fleichman Effect

Pons and Fleichman announced 1989 [C11] the production of heat of with unknown origin in an electrolytic system using palladium metal as catode immersed in heavy water (D_2O). The heat production was assigned to cold fusion. The prevailing interpretation has been that electrolysis brings deuterium to the porous surface of Palladium and at some critical doping ratio near to 1:1 cold fusion at Pd target becomes possible.

The E-Cat of Andrea Rossi [C12] can be also classified as cold fusion device although the mechanism of the claimed fusion is still unknown. Several objections against Rossi's E-Cat are represented: I have discussed the objections from TGD viewpoint in [K3]. For instance, isotope ratios for Cu produced in the process are same as the natural isotope ratios and that only stable isotopes are present. This has been interpreted by skeptics in an easy-to-guess manner: the Cu isotopes are added by hand. This requires that cold fusion mechanism is very similar to the standard nuclear fusion or behind it.

Criticality could be a prerequisite for both the generation of dark variants of particles and their transformation to ordinary nuclei. At critical doping fraction either a transformation of deuterium to dark deuterium or of the dark nuclei generated in dark bubble fusion to ordinary ones in electrolyte could take place. Therefore TGD allows to consider two alternative models and also their hybrid in these situations.

1. The earlier arguments suggest that the critical doping fraction makes it possible for the incoming dark nuclei generated in the bubble fusion in the electrolyte to transform to ordinary nuclei in especially effective manner. The dark bubble fusion near Pd surface or inside pores of the Pd target could dominate and give rise to dark sequences of D nuclei (heavy water was used by Pons and Fleichman). Large fraction of the dark nuclei from the electrolyte far from electrodes could leak out from the system.

   As already explained, SPPs would help to generate strong negative local charge density at the surface of Pd attracting the positively charged dark nuclei and inducing their transformation to ordinary nuclei.

2. Second option is that dark fusion occurs mostly at the pores of Pd surface at critical doping fraction. It is not however not easy to identify for this any other mechanism than bubble collapse in the pore. Pd catalyst could make dark bubble fusion especially effective by forcing also the Pd nuclei at Pd surface to the compressed dark phase. SPPs at the surface of Pd catalyst could in turn attract the dark nuclei and force them to transform to ordinary ones. Criticality would act in both directions.

   (a) It is known that deuterium nuclei are gradually adsorbed at the surface of Palladium catalyst, where they have a high mobility. Bubble collapse could draw these highly mobile Pd nuclei to the dark nuclei at flux tubes.

   (b) The larger the density of deuterons at Pd surface, the better the changes to achieve the generation of dark nuclei. It takes quite a long time before heat production begins, which suggests that the critical doping fraction implies quantum criticality making possible effective beneration of dark nuclei and their transformation back to ordinary nuclei. This argument makes sense also when bubble collapse in pores induces the dark fusion.

   (c) If only the production of dark nuclei takes place at Pd surface, heat production could be due to the emission of keV dark photons transforming to ordinary X rays. The dark nuclei could leak out of the system and remain undetected. Dark nuclei could also remain in the Palladium or Nickel target and be rather long-lived against transformation to ordinary nuclei so that their presence would eventually prevent the generation of new dark nuclei. It would be also easy to understand why dark nuclei do not leak out out so easily in cold fusion with Pd and Nickel targets as in say bubble fusion. The production of heat is indeed observed to occur periodically. The dead times between heat production periods give idea about the lifetime of dark nuclei.

   (d) SPPs could also attract dark nuclei and transform them to ordinary nuclei and enhance production of heat and ordinary nuclei.

The cautious conclusion would be following. The production of dark nuclei occurs always as dark bubble fusion but the dark nuclei generated in electrolyte tend to leak out from the system. Metal surfaces in electric fields inducing negative charge density could help to transform dark nuclei to ordinary ones. Mobile D-nuclei at the surface of Pd electrode could make dark fusion more effective in the pores. SPPs at Pd surface cold also make the transformation of dark nuclei to ordinary nuclei more effective.

3.2 Solution Of The Ni62 Mystery Of Rossi's E-Cat

In my blog (see `http://tinyurl.com/zvqfqkt`) a reader calling himself Axil made a highly interesting comment. He told that in the cold fusion ashes from Rossi's E-Cat there is 100 micrometer sized block containing almost pure Ni62 isotope. This is one of Ni isotopes but not the lightest Ni58, whose isotope fraction 67.8 per cent. Axil gave a link providing additional information (see `http://tinyurl.com/zsv8jfe`) and I dare to take the freedom to attach it here.

Ni62 finding looks really mysterious. One interesting finding is that the size 100 micrometers of the Ni62 block corresponds to the secondary p-adic length scale for W bosons. Something deep? Let us however forget this clue.

One can imagine all kinds of exotic solutions but I guess that it is the reaction kinetics "dark fusion + subsequent ordinary fusion repeated again and again", which leads to a fixed point, which is enrichment of Ni62 isotope. This is like iteration. This guess seems to work!

1. The reaction kinematics in the simplest case involves three elements.

   (a) The addition of protons to stable isotopes of Ni. One can add $N = 1, 2, ...$ protons to the stable isotope of Ni to get dark nuclear string NiX+N protons. As such these are not stable by Coulomb repulsion.

   (b) The allowed additional stabilising reactions are dark weak decays and dark W boson exchanges, which transfer charge between separate dark nuclear strings at flux tubes. Ordinary beta decays are very slow processes since outgoing W boson decaying to electron and neutrino is very massive. One can forget them.

   (c) The generation of dark nuclei and their transformation to ordinary nuclei occurs repeatedly. Decay products serve as starting point at the next round. One starts from stable isotopes of NiX, $X = 58, 60, 61, 62, 64$ and adds protons some of which can by dark W exchange transform to neutrons. The process produces from isotope NiX heavier isotopes NiY, $Y = X + 1, X + 2, ..$ plus isotopes of Zn with $Z = 30$ instead of $Z = 28$, which are stable against ordinary beta decays in the time scale considered. They can however decay by dark beta decay to a possibly stable isotope of Ni.

2. The key observation is that this iterative kinematics increases necessarily mass number!! The first guess is that starting from say $X = 58$ one unavoidably ends up to the most massive stable isotope of Ni! The problem is however that Ni62 is not the heaviest stable isotope of Ni: it is Ni64!! Why the sequence does not continue up to Ni64?

   The problem can be solved. The step Ni62 $\rightarrow$ Ni62+p leads to Cu63, which is the lightest stable isotope of Copper. No W exchanges or beta decays anymore and the iteration stops! It works!

3. But how so huge pieces of Ni62 are possible? If dark W bosons are effectively massless only below atomic length scale - the minimal requirement - , one cannot expect pieces to be much larger than atomic length scale. Situation changes if the Planck constant for dark weak interactions is so large that the scaled up weak scale corresponds to secondary p-adic length scale. This requires $h_{eff}/h \sim 2^{45} \simeq 3.2 \times 10^{13}$. The values of Planck constant in living matter are of this order of magnitude and imply that 10 Hz EEG photons have energies in visible and UV range and can transform to ordinary photons identifiable as bio-photons ideal for the control of bimolecular transitions! 100 micrometers in turn is the size scale of large neuron! So large value of h_{eff}/h would also help to understand why large breaking of parity symmetry realized as chiral selection is possible in cellular length scales.

Clearly, this kind of fixed point dynamics is the unique feature of the proposed dark fusion dynamics and provides an easily testable prediction of TGD based model. Natural isotope fractions are not produced. Rather, the heaviest stable isotope dominates unless there is lighter stable isotope which gives rise to stable isotope by addition of proton.

3.3 Sonofusion

In sonoluminescence (see `https://en.wikipedia.org/wiki/Sonoluminescence`) external sound source induces oscillation of the radius of a bubble of water containing possibly 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.

The term sonofusion or bubble fusion is used about this effect (`https://en.wikipedia.org/wiki/Bubble_fusion`). Taleyarkhan and collaborators [C10] claimed of having observed sonofusion and also neutrons expected to be emitted in the process in 2002 but the experiments could not be replicated. The claim was met with allegations ranging from experimental error to academic fraud, and Taleyarkhan lost his professorship. It is very difficult for an academic outsider to tell what the truth is since the tone of Wikipedia article is extremely hostile.

In standard physics framework one could try to understand sonofusion in terms of very dense phase resulting in bubble collapse making possible high local temperature and the analog of hot fusion. In the master dissertation of M. C. Ramsey spherically symmetric cavitation is modelled using hydrodynamics and also studied experimentally (see `http://tinyurl.com/hspj78t`). The conclusion is that temperatures higher than 10^4 K can be achieved but there is no evidence for extreme temperatures of order 10^7 K required to initiate thermonuclear fusion reactions in Sun (proceeding extremely slowly!).

In TGD framework the low temperature need not be a problem.

1. Also now the model based on dark nuclei at magnetic flux tubes looks natural. Flux tubes would be now radial flux tubes and probably carry monopole flux so that they should return along some axis and thus form the TGD analog of Dirac monopole possible also in Maxwell's electrodynamics albeit asa singular object. In the case of water dark hydrogen strings and even dark oxygen strings can be considered.

2. Dark nucleus phase would be formed during the contraction of the bubble. Since the dark nuclei receive momentum in radial direction, one expects that they continue to travel along the magnetic flux tubes and leak out from the system: a collision with a target might change the situation. The transformation of the nuclei to a string of dark nuclei would involve emission of dark photons with energies corresponding to scaled down binding energies which are in keV range for $k = 127$ and transforming to ordinary photons heating the system. The transformation to ordinary nuclei could generate gamma rays. If the lifetimes of dark nuclei are relatively long as suggested by the observations of cold fusion in Pd target, the observation of reaction products inside bubbles would be difficult.

3.4 Leclair Effect

The original idea of cavitation induced fusion differs from bubble induced fusion in that the bubbles are not assumed to be completely spherical and the expansion is like explosion producing jets. Asymmetric cavitation leads to a situation in which the expansion of the bubble takes place in asymmetric manner and jets are created. Microjets are a real phenomenon (see `http://tinyurl.com/oopu3p2`), they accompany cavitation, and are proposed as an explanation of the corrosive effects produced by cavitation to metal surfaces. The physical mechanism causing the effects remains however open. Also cold fusion experimenters report similar effects. The interpretation would be as effects caused by the energy liberated in cold fusion: in TGD framework the fusion could have produced dark nuclei and their collisions with the target could have transformed them to ordinary nuclei liberating large energies and leading to corrosion.

LeClair has studied the possibility that microjets associated with cavitation of water could lead to cold fusion (see `https://nanospireinc.com/Fusion.html`). What would be remarkable the simplicity of the approach. Only water would be needed to build all elements and also produce nuclear energy. In [L3] I considered this possibility in the framework of TGD based model for the Pollack's fourth phase of water involving charge separation (negatively charged exclusion zones). Also LeClair reports charge separation and also the geometry of the cross section of jets resembles that of the EZs .

Consider first the claimed findings.

1. Three separate independent scanning electron microscope elemental analysis of the transmuted material were carried out. Also analysis known as XPS and SEM were performed. According to these analysis, the nuclei of almost all elements were produced. The composition transmuted materials followed the same patter as supernova nucleosynthesis, mostly carbon and oxygen with decreasing amounts of the heavier elements. The elemental distribution followed the saw-tooth shaped astronomers's odd-even rule, elements because of the dominance of alpha particle fusion.

   All rare earth metals, precious metals, and many other key elements are reported to be produced in high concentrations, greater than typically seen in the naturally occurring ores. The surface of the reactor was covered with diamonds. These claims sound like commercials and it is difficult to take them seriously.

   Some cold fusion researchers have commented the data and say that the reports about production of heavier nuclei can be true but that they would not try to replicate the experiments. What raises doubts that despite the claimed dramatic successes LeClair did not continue the experimentation (see http://tinyurl.com/q3fzrzq). Since public documents are missing, skeptics consider even the possibility of fraud.

In TGD framework the claim about production of all nuclei could be challenged. If dark nuclei consist of protons and if beta decays of dark protons are not fast enough (they could be rather stable, and neutron containing nuclei would be produced only in the collision with the reaction core leading to the decay of unstable nuclei consisting of protons either decaying to protons. Of course, also dark nuclei containing only protons could be unstable. Dark nuclei could however stabilize themselves rather rapidly by dark beta decays of protons to neutrons if weak bosons are dark and thus effectively massless in the scale $L(127)$.

2. Detailed claims about the shape of jets are made and told to resemble bacteriophages(!) (see https://en.wikipedia.org/wiki/Bacteriophage) with head and tail. Head is reported to be positively charged and tail negatively charged. The cylindrical structure is reported to have a cross section consisting of triangles forming hexagons. Inside the negatively charged exclusion zones (EZs) associated with the fourth phase of water discovered by Pollack [L1] obeys effective stoichiometry $H_{3/2}O$ and consists of layers having hexagonal structure. Could jets represent fourth phase of water discovered by Pollack. Personally I would take these claims very cautiously but I am not experimentalist.

3. There are also claims about a corrosion like effects in the nearby environment. These claims sound outlandish but if the dark nuclei indeed transform to ordinary one liberating large nuclear binding energy in collisions with say walls, this could happen. LeClair also tells about radiation sickness: also this claim could make sense after all.

Unfortunately, the situation is not improved by the fact that the theoretical claims of LeClair do not make much sense. Experimentalists should avoid theorizing as too risky business and leave it to theoreticians who are allowed to be wrong (it would be nice if they would be allowed to be also right!).

1. LeClair interprets the jets as crystal like particle moving with supersonic velocities accelerating to relativistic velocities at which Coulomb wall can be overcome and ordinary nuclear reactions become possible in collisions with aluminium sheets forming the core of the fusion reactor. The reported trenches in the sheet would be due to the collision of jets with the sheet and if the collision is not orthogonal to the sheet a trench is produced.

   The model of bubble fusion involving dark nuclei leaking out from the bubble would allow to interpret the jets as dark matter. They could move with super-sonic velocities since the scale for kinetic energies would be $k = 127$ in the proposed model. The velocities would be of order $v/c = \sqrt{2E/mc^2} \sim 10^{-3}$ for kinetic energy scale $E \sim$ keV. In TGD framework the dark nuclear fusions would have occurred in the bubble and only the decays to ordinary nuclei would occur at the target. The target would be heated but probably and one cannot exclude that ordinary nuclear fusions occur also in the target.

   The claim about relativistic velocities is non-sensical since the energy needed to achieve them would be a considerable fraction of the mass of the crystal. If the crystal has size of order 1 μm the energy would be about 10 Joules and about thousand times larger than the energy liberated in cold fusion if all the protons in this volume fuse to heavier nuclei.

2. LeClair introduces also ZPE as the source of energy and says that nuclear fusion is actually un-necessary. Also Casimir effect is introduced as interaction between the shock bow and jet with Coulomb attraction somehow giving rise to the acceleration of the jet. This s does not make sense to me.

3. LeClair talks about bow shock associated with the moving crystal and carrying negative charges. The geometry of the crystal would resemble bacteriophage having positively charged tail and negatively charged tail. I cannot comment these claims since I do not know about the possibilities to make so detailed conclusions and do not really understand what is meant. The motivation of LeClair probably comes from nuclear fusion believed to occur in the shock wave zones of supernovas and he claims that the situation is scaled down variant of this situation.

> The idea about the role of shock waves could make sense in TGD framework: shock wave would create in the direction of propagation of shock wave $k = 127$ dark nuclei at flux tubes in its propagation direction. In the recent case it does not seem to make sense since the dark nuclei would be generated during the contraction phase of the bubble.

As already noticed, the TGD inspires proposal electrolysis reduces to bubble fusion would suggest that LeClair has rediscovered Brown's gas and its effects on metals having interpretation as a transformation of dark nuclei to ordinary ones (see `https://en.wikipedia.org/wiki/Oxyhydrogen`) .

The conclusion of skeptic on basis of these objections would be rather obvious. However, in TGD framework the cavitation induced fusion is essentially identical with the bubble fusion except that the reactor core of LeClair might make possible the transformation of the produced dark nuclei to ordinary nuclei so that they would not leak out from the system. If the results of LeClair survive his arrangement allows to transform the dark nuclei generated in bubble fusion and to ordinary nuclei and liberate also large energy. This would be an enormous technological breakthrough.

3.5 Is cold fusion becoming a new technology?

The progress in cold fusion research has been really fast during last years and the most recent news might well mean the final breakthrough concerning practical applications which would include not only wasteless energy production but maybe also the production of elements such as metals. The popular article titled "Cold Fusion Real, Revolutionary, and Ready Says Leading Scandinavian Newspaper" (see `http://tinyurl.com/huqc34y`) tells about the work of Prof. Leif Holmlid and his student Sinder-Zeiner Gundersen. For more details about the work of Holmlid et al see `http://tinyurl.com/nbephxb` and `http://tempid.altervista.org/SRI.pdf`, `http://tinyurl.com/pm56kk3` and [C3].

Gundersen revealed the details of an operating cold fusion reactor in Norway reported to generate 20 times more energy than required to activate it. The estimate of Holmlid is that Norway would need 100 kg of deuterium per year to satisfy its energy needs (this would suggest that the amount of fusion products is rather small to be practical except in situations, where the amounts needed are really small). The amusing co-incidence is that I constructed towards the end of the last year a detailed TGD based model of cold fusion and the findings of Leif Holmlid already discussed served as an important guideline although the proposed mechanism is different.

Histories are cruel, and the cruel history of cold fusion begins in 1989, when Pons and Fleichmann reported anomalous heat production involving palladiums target and electrolysis in heavy water (deuterium replacing hydrogen). The reaction is impossible in the world governed by text book physics since Coulomb barrier makes it impossible for positively charged nuclei to get close enough. If ordinary fusion is in question, reaction products should involve gamma rays and neutrons and these have not been observed.

The community preferred text books over observations and labelled Pons and Fleichman and their followers as crackpots and it became impossible to publish anything in so called respected journals. The pioneers have however continued to work with cold fusion and for few years ago American Chemical Society had to admit that there might be something in it and cold fusion researchers got a status of respectable researcher. There have been several proposals for working reactors such as Rossi's E-Cat and NASA is performing research in cold fusion. In countries like Finland cold fusion is still a cursed subject and will probably remain so until cold fusion becomes the main energy source in heating of also physics department.

3.5.1 The model of Holmlid for cold fusion

Leif Holmlid is a professor emeritus in chemistry at the University of Gothemburg. He has quite recently published a work on Rydberg matter in the prestigious journals of APS and is now invited to tell about his work on cold fusion to a meeting of American Physical Society.

1. Holmlid regards Rydberg matter (see `https://en.wikipedia.org/wiki/Rydberg_matter`) as a probable precursor of cold fusion. Rydberg atoms have some electrons at very high orbitals with large radius. Therefore the nuclei plus core electrons look for them like a point

nucleus, which charge equal to nuclear charge plus that of core electrons. Rydberg matter forms layer-like structures with hexagonal lattice structure.

2. Cold fusion would involve the formation of what Holmlid calls ultra-dense deuterium having Rydberg matter as precursor. If I have understood correctly, the laser pulse hitting Rydberg matter would induce the formation of the ultra-dense phase of deuterium by contracting it strongly in the direction of the pulse. The ultra-dense phase would then suffer Coulomb explosion. The compression seems to be assumed to happen in all directions. To me the natural assumption would be that it occurs only in the direction of laser pulse defining the direction of force acting on the system.

3. The ultra-dense deuterium would have density about $.13 \times 10^6 kg/m^3$, which is 1.3×10^3 times that of ordinary water. The nuclei would be so close to each other that only a small perturbation would make possible to overcome the Coulomb wall and cold fusion can proceed. Critical system would be in question. It would be hard to predict the outcome of individual experiment. This would explain why the cold fusion experiments have been so hard to replicate. The existence of ultra-dense deuterium has not been proven but cold fusion seems takes place.

   Rydberg matter, which should not be confused with the ultra-dense phase would be the precursor of the process. I am not sure whether Rydberg matter exists before the process or whether it would be created by the laser pulse. Cold fusion would occur in the observed microscopic fracture zones of solid metal substances.

3.5.2 Issues not so well-understood

The process has some poorly understood aspects.

1. Muons as also of mesons like pion and kaon are detected in the outgoing beam generated by the laser pulse. Muons with mass about 106 MeV could be decay products of pions with mass of 140 MeV and kaons but how these particles with masses much larger than scale of nuclear binding energy per nucleon of about 7-8 MeV for ligher nuclei could be produced even if low energy nuclear reactions are involved? Pions appear as mediators of strong interaction in the old-fashioned model of nuclear interactions but the production on mass shell pions seems very implausible in low energy nuclear collisions. Something very strange seems to be occurring.

2. What is even stranger that muons produced even when laser pulse is not used to initiate the reaction. Holmlid suggests that there are two reaction pathways for cold fusion: with and without the laser pulse. This forces to ask whether the creation of Rydberg matter or something analogous to it is alone enough to induce cold fusion and whether the laser beam actually provides the energy needed for this so that ultra-dense phase of deuterium would not be needed at all. Coulomb wall problem would be solve in some other manner.

3. The amount of gamma radiation and neurons is small so that ordinary cold fusion does not seem to be in question as would be implied by the proposed mechanism of overcoming the Coulomb wall. Muon production would suggest muon catalyzed fusion as a mechanism of cold fusion but also this mechanism should produce gammas and neutrons.

3.5.3 TGD inspired model of cold fusion

It seems that Holmlid's experiments realize cold fusion and that cold fusion might be soon a well-established technology. A real theoretical understanding is however missing. New physics is definitely required and TGD could provide it.

1. TGD based model of cold fusion relies on TGD based view about dark matter. Dark matter would correspond to phases of ordinary matter with non-standard value of Planck constant $h_{eff} = n \times h$ implying that the Compton sizes of elementary particles and atomic nuclei are scaled up by n and can be rather large - of atomic size or even larger.

Also weak interactions can become dark: this means that weak boson Compton lengths are scaled up so that they are effectively massless below Compton length and weak interactions become as strong as electromagnetic interactions. If this happens, then weak interactions can lead to rapid beta decay of dark protons transforming them to neutrons (or effectively neutrons as it turns out). For instance, one can imagine that proton or deuteron approaching nucleus transforms rapidly to neutral state by exchange of dark W bosons and can overcome the Coulomb wall in this manner: this was my original proposal for the mechanism of cold fusion.

2. The model assumes that electrolysis leads to a formation of so called fourth phase of water discovered by Pollack. For instance, irradiation by infrared light can induce the formation of negatively charged exclusion zones (EZs) of Pollack. Maybe also the laser beam used in the experiments of Holmlid could do this so that compression to ultra-dense phase would not be needed. The fourth phase of water forms layered structures consisting of 2-D hexagonal lattices with stoichiometry $H_{1.5}O$ and carrying therefore a strong electric charge. Also Rydberg matter forms this kind of lattices, which suggests a connection with the experiments of Holmlid.

   Protons must go somewhere from the EZ and the interpretation is that one proton per hydrogen bonded pair of water molecules goes to a flux tube of the magnetic body of the system as dark proton with non-standard value of Planck constant $h_{eff} = n \times h$ and forms sequence of dark protons forming dark nucleus. If the binding energy of dark nucleus scales like $1/h_{eff}$ (1/size) the binding energy of dark nucleus is much smaller than that for ordinary nucleus. The liberated dark nuclear binding energy in the formation would generate further EZs and one would have a kind of chain reaction.

   In fact, this picture leads to the proposal that even old and boring ordinary electrolysis involves new physics. Hard to confess, but I have had grave difficulties in understanding why ionization should occur at all in electrolysis! The external electric field between the electrodes is extremely weak in atomic scales and it is difficult to understand how it induce ionization needed to load the electric battery!

3. The dark proton sequences need not be stable - the TGD counterpart for the Coulomb barrier problem. More than half of the nucleons of ordinary nuclei are neutrons and similar situation is the first expectation now. Dark weak boson (W) emission could lead to dark beta decay transforming proton to neutron or what looks like neutron (what this cryptic statement means would requires explanation about nuclear string model). This would stabilize the dark nuclei.

   An important prediction is that dark nuclei are beta stable since dark weak interactions are so fast. This is one of the predictions of the theory. Second important prediction is that gamma rays and neutrons are not produced at this stage. The analogs of gamma rays would have energies of order dark nuclear binding energy, which is ordinary nuclear energy scale scaled down by $1/n$. Radiation at lower energies would be produced. I have a vague memory that X rays in keV range have been detected in cold fusion experiments. This would correspond to atomic size scale for dark nuclei.

4. How the ordinary nuclei are then produced? The dark nuclei could return back to negatively charged EZ (Coulomb attraction) or leave the system along magnetic flux tubes and collide with some target and transform to ordinary nuclei by phase transition reducing the value of h_{eff}. It would seem that metallic targets such as Pd are favorites in this respect. A possible reason is that metallic target can have negative surface charge densities (electron charge density waves are believed by some workers in the field to be important for cold fusion) and attract the positively charged dark nuclei at magnetic flux tubes.

   Essentially all of the nuclear binding energy would be liberated - not only the difference of binding energies for the reacting nuclei as in hot fusion. At this stage also ultra-dense regions of deuterium might be created since huge binding energy is liberated and could induce also ordinary fusion reactions. This process would create fractures in the metal target.

   This would also explain the claimed strange effects of so called Brown's gas generated in electrolysis on metals: it is claimed that Brown's gas (one piece of physics, which serious academic physicists enjoying monthly salary refuse to consider seriously) can melt metals although its temperature is not much more than 100 degrees Celsius.

5. This model would predict the formation of beta stable nuclei as dark proton sequences transform to ordinary nuclei. This process would be analogous to that believed to occur in super-nova explosions and used to explain the synthesis of nuclei heavier than iron. This process could also replace the hypothesis about super-nova nucleosynthesis: indeed, SN1987A did not provide support for this hypothesis.

   The reactor of Rossi is reported to produce heavier isotopes of Ni and of Copper. This would strongly suggest that protons also fuse with Ni nuclei. Also heavier nuclei could enter to the magnetic flux tubes and form dark nuclei with dark protons transformed partially to neutral nucleons. Also the transformation of dark nuclei to ordinary nuclei could generate so high densities that ordinary nuclear reactions become possible.

6. What about the mysterious production of pions and mesons producing in turn muons?

   (a) Could the transformation of nuclei to ordinary nuclei generate so high a local temperature that hadron physics would provide an appropriate description of the situation. Pion mass corresponds to 140 MeV energy and huge temperature about .14 GeV. This is much higher than solar temperature and looks totally implausible.

   (b) The total binding energy of nucleus with 70 nucleons (average binding energy per nucleon around 7 MeV) as single meson would generate energy of the order of magnitude of kaon mass. Dark nuclei are quantum coherent structures: could this make possible this kind of "holistic" process in the transformation to ordinary nucleus. This might be part of the story.

   (c) How the mesons are created? The first option is that the transformation of dark nucleus to ordinary one creates few mesons: the binding energy of the ordinary nucleus would be liberated as meson. This would conform with the holistic nature of the process occurring as phase transition rather than as transformation of individual dark nucleons to ordinary ones. The completely mysterious looking emission of mesons from usually detected in hadronic reactions in much higher energy scale would be a direct signature of the process.

       Or could the transformation to ordinary nucleus involve the emission of dark W boson with mass about 80 GeV decaying to dark quark pairs binding to dark mesons transforming eventually to ordinary mesons? Could dark W boson emission occur quantum coherently so that the amplitude would be sum over the emission amplitudes, and one would have an amplification of the decay rate so that it would be proportional to the square of dark nuclear charge? The effective masslessness below atomic scale would make the rate for this process high. The emission would lead directly to the final state nucleus by emission of on mass shell mesons.

   (d) One objection against the proposed model of cold fusion is that the energy liberated in the transformation of dark nuclei to ordinary ones is so large that it should have been detected. A possible explanation is that most of the energy is liberated as mesons and leaks out of the system. Fusion products would be however detected.

3.6 Could Pollack effect make cell membrane a self-loading battery?

The so called Clarendon dry pile is 175 years old battery still working. The current is very weak (nano Ampere) but the working of the battery is claimed to be not well-understood. The TGD inspired model for cold fusion leads to the proposal that Pollack effect is part of electrolysis. This inspires the idea that Pollack effect and possibly also the associated cold fusion could make Clarendon dry pile a self-loading battery. Cell membrane can be regarded as the analog of self-loading battery, and in TGD framework also as a generalised Josephson junction. Hence one can ask whether also cell membrane could be seen as a self-loading battery utilizing Pollack's mechanism. This would also allow to understand why hyperpolarization stabilizes the membrane potential and why depolarization generates nerve pulse.

3.6.1 Clarendon pile: 175 years old battery still working

Elemer Rosinger had a Facebook link to an article telling about Clarendon dry pile, a very long-lived battery providing energy for an electric clock (see http://tinyurl.com/zeut69y, http://tinyurl.com/jhrww2a, and http://tinyurl.com/gvbrhra). This clock known also as Oxford bell has been ringing for 175 years now and the article suggests that the longevity of the battery is not really understood. The bell is not actually ringing so loud that human ear could hear it but one can see the motion of the small metal sphere between the oppositely charged electrodes of the battery in the video.

The function principle of the clock is simple. The gravitational field of earth is also present. When the sphere touches the negative electrode, it receives a bunch of electrons and gives the bunch away as it touches positive electrode so that a current consisting of these bunches is running between electrons. The average current during the oscillation period of 2 seconds is nanoampere so that nanocoulomb of charge is transferred during each period (Coulomb corresponds to a 6.242×10^{18} elementary charges (electrons)).

The dry pile was discovered by priest and physicist Giuseppe Zamboni at 1812 (see http://tinyurl.com/jkvtj6f). The pile consists of 2,000 pairs of pairs of discs of tin foil glued to paper impregnated with Zinc sulphate and coated on the other side with manganese dioxide: 2,000 thin batteries in series. The operation of battery gradually leads to the oxidation of Zinc and the loss of magnase dioxide but the process takes place very slowly. One might actually wonder whether it takes place too slowly so that some other source of energy than the electrostatic energy of the battery would be keep the clock running. Karpen pile is analogous battery discover by Vasily Karpen (see http://www.greenoptimistic.com/karpen-pile/#.V9JMiceHvJA). It has now worked for 50 years.

Cold fusion is associated with electrolysis. Could the functioning of this mystery clock involve cold fusion taken seriously even by American Physical Society thanks to the work of the group of prof. Holmlid. Electrolytes have of course been "understood" for aeons. Ionization leads to charge separation and current flows in the resulting voltage. With a feeling of deep shame I must confess that I cannot understand how the ionization is possible in standard physics. This of course might be just my immense stupidity - every second year physics student would immediately tell that this is "trivial" - so trivial that he would not even bother to explain why. The electric field between the electrodes is immensely weak in the scale of molecules. How can it induce the ionisation? Could ordinary electrolytes involve new physics involving cold fusion liberating energy? These are the questions which pop up in my stupid mind. Stubborn as I am in my delusions, I have proposed what this new physics might be with inspiration coming from strange experimental findings of Gerald Pollack, cold fusion, and my own view about dark matter has phases of ordinary matter with non-standard value $h_{eff} = n \times h$ of Planck constant. Continuing with my weird delusions I dare ask: Could cold fusion provide the energy for the "miracle" battery?

3.6.2 What batteries are?

To understand what might be involved one must first learn some basic concepts. I am trying to do the same.

1. Battery (see http://tinyurl.com/8xqsnab) consistes of two distinct electrochemical cells (see http://tinyurl.com/jq8ljmo). Cell consists of electrode and electrolyte. The electrodes are called anode and catode. By definition electron current along external wire flows to catode and leaves anode.

2. There are also ionic currents flowing inside the battery. In absence of the ionic currents the electrodes of the battery lose their charge. In the loading the electrodes get their charges. In the ideal situation the ionic current is same as electron current and the battery does not lose its charging. Chemical reactions are however taking place near and at the electrodes and in their reversals take place during charging. Chemical changes are not completely reversible so that the lifetime of the battery is finite.

   The ionic current can be rather complex: the carriers of the positive charge from anode can even change during the charge transfer: what matters that negative charge from catode is transferred to anode in some manner and this charge logistics can involve several steps. Near the catode the currents of positive ions (cations) and electrons from the anode combine to form neutral molecules. The negative current carriers from catode to the anode are called anions.

3. The charge of the clectrochemical cell is in the electrolyte near the surface of the electrode rather than inside it as one might first think and the chemical processes involve neutralization of ion and the transfer of neutral outcome to or from the electrode.

4. Catode - or better, the electrochemical cell containing the catode - can have both signs of charge. For positive charge one has a battery liberating energy as the electron current connecting the negative and positive poles goes through the load, such as LED. For negative charge current flows only if there is external energy feed: this is loading of the battery. External voltage source and thus energy is needed to drive the negative charges and positive charges to the electrodes. The chemical reactions involved can be rather complex and proceed in reverse direction during the loading process. Travel phone battery is a familiar example.

   During charging the roles of the anode and catode are changed: understanding this helps considerably.

3.6.3 Could dark cold fusion make possible self-loading batteries?

Could cold fusion help to understand why the Clarendon dry pile is so long lived?

1. The battery is series of very many simpler batteries. The mechanism should reduce to the level of single building brick. This is assumed in the following.

2. The charge of the battery tends to be reduced unless the ionic and electronic currents are identical. Also chemical changes occur. The mechanism involved should oppose the reduction of the charging by creating positive charge to the catode and negative charge to the anode or induce additional voltage between the electrodes of the battery inducing its loading. The energy feed involved might also change the direction of the basic chemical reactions as in the ordinary loading by raising the temperature at catode or anode.

3. Could be formation of Pollack's exclusion zones (EZs) in the elecrolytic cell containing the anode help to achieve this? EZs carry a high electronic charge. According to TGD based model protons are transformed to dark protons at magnetic flux tubes. If the positive dark charge at the flux tubes is transferred to the electrolytic cell containing catode and transformed to ordinary charge, it would increase the positive charge of the catode. The effect would be analogous to the loading of battery. The energy liberated in the process would compensate for the loss of charge energy due to electronic and ionic currents.

4. In the ordinary loading of the battery the voltage between batteries induces the reversal of the chemical processes occurring in the battery. This is due to the external energy feed. Could the energy feed from dark cold fusion induce similar effects now? For instance, could the energy liberated at the catode as positively charged dark nuclei transform to ordinary ones raise the temperature and in this manner feed the energy needed to change the direction of the chemical reactions.

3.6.4 Cell membrane as self-loading battery and how nerve pulse is generated?

This model might have an interesting application to the physics of cell membrane.

1. Cell membrane consisting of two lipid layers defines the analog of a battery. Cell interior plus inner lipid layer (anode) and cell exterior plus outer lipid layer (catode) are analogs of electrolyte cells.

   What has been troubling me for two decades is how this battery manages to load itself. Metabolic energy is certainly needed and ADP-ATP mechanism is essential element. I do not however understand how the membrane manages to keep its voltage.

   Second mystery is why it is hyperpolarization rather than polarization, which tends to stabilize the membrane potential in the sense that the probability for the spontaneous generation of nerve pulse is reduced. Neither do I understand why depolarization (reduction of the membrane voltage) leads to a generation of nerve pulse involving rapid change of the sign of the membrane voltage and the flow of various ionic currents between the interior and exterior of the cell.

2. In the TGD inspired model for nerve pulse cell interior and cell exterior or at least their regions near to lipid layers are regarded as super-conductors forming a generalized Josephson junction. For the ordinary Josephson junction the Coulombic energy due to the membrane voltage defines Josephson energy. Now Josephson energy is replaced by the ordinary Josephson energy plus the difference of cyclotron energies of the ion at the two sides of the membrane. Also ordinary Josephson radiation can be generated. The Josephson currents are assumed to run along magnetic flux tubes connecting cell interior and exterior. This assumption receives support from the strange finding that the small quantal currents associated with the membrane remain essentially the same when the membrane is replaced with polymer membrane.

3. The model for Clarendon dry pile suggests an explanation for the self-loading ability. The electrolytic cell containing the anode corresponds to the negatively charged cell interior, where Pollack's EZs would be generated spontaneously and the feed of protonic charge to the outside of the membrane would be along flux tubes as dark protons to minimize dissipation. Also ions would flow along them. The dark protons driven to the outside of the membrane transform to ordinary ones or remain dark and flow spontaneously back and provide the energy needed to add phosphate to ADP to get ATP.

4. The system could be quantum critical in the sense that a small reduction of the membrane potential induces nerve pulse. Why the ability to generate Pollack's EZs in the interior would be lost for a few milliseconds during nerve pulse? The hint comes from the fact that Pollack's EZs can be generated by feeding infrared radiation to a water bounded by gel. Also the ordinary Josephson radiation generated by cell membrane Josephson junction has energy in infrared range!

   Could the ordinary Josephson radiation generate EZs by inducing the ionization of almost ionized hydrogen bonded pairs of water molecules. The hydrogen bonded pairs must be very near to the ionization energy so that ordinary Josephson energy of about .06 eV assignable to the membrane voltage is enough to induce the ionization followed by the formation of $H_{3/2}O$. The resulting EZ would consist of layers with the effective stoichiometry $H_{3/2}O$.

   As the membrane voltage is reduced, Josephson energy would not be anymore enough to induce the ionization of hydrogen bonded pair of water molecules, EZs are not generated, and the battery voltage is rapidly reduced: nerve pulse is created. In the case of hyperpolarization the energy excees the energy needed for ionization and the situation becomes more stable.

5. This model could also allow to understand the effect of anesthetes [K12] [L5]. Anesthetes could basically induce hyperpolarization so that Josephson photons would continually generate Pollack's EZ:s and creating of dark particles at the magnetic flux tubes. This need not mean that consciousness is lost at the cell level. Only sensory and motor actions are prevented because nerve pulses are not possible. This prevents formation of sensory and motor mental images at our level of hierarchy.

   Meyer-Overton correlation states that the effectiveness of the anesthete correlates with its solubility to the lipid membrane. This is the case if the presence of anesthete in the membrane induces hyperpolarization so that the energies of the photons of Josephson radiation would be higher than needed for the generation of EZs accompanied by magnetic flux tubes along which ionic Josephson currents would flow between cell interior and exterior. For these quantal currents evidence exists [K10]. In the case of battery these dark ions would flow from the cell containing anode to that containing catode. For depolarization the energy of Josephson photons would be too low to allow the kicking off protons from hydrogen bonded pairs of water molecules so that EZs would not be created and self-loading would stop and nerve pulse would be generated.

4 Could cold fusion solve some problems of the standard view about nucleosynthesis?

The theory of nucleosynthesis involves several uncertainties and it is interesting to see whether interstellar cold fusion could provide mechanisms allowing improved understanding of the observed abundances. There are several problems: D abundance is too low unless one assumes the presence of dark matter/energy during Big Bang nucleosynthesis (BBN); there are two Lithium anomalies; there is evidence for the synthesis of boron during BBN; for large redshifts the observed metallic abundances are lower than predicted. The observed abundances of light nuclei are higher than predicted and require that so called cosmic ray spallation producing them via nuclear fission induced by cosmic rays. The understanding of abundances of nuclei heavier than Fe require supernova nucleosynthesis: the problem is that supernova 1987A did not provide support for the r-process.

The idea of dark cold fusion could be taken more seriously if it helped to improve the recent view about nucleosynthesis. In the sequel I try to develop a systematic view about how cold fusion could help. I take as a starting point the model for cold dark fusion already discussed. This model could be seen as generalization of supernova nucleosynthesis in which dark variant of neutron and proton capture gives rise to more massive isotopes. Also a variant allowing the capture of dark alpha particle can be considered.

4.1 Standard view about nucleosynthesis

To learn some background it is good to read Wikipedia articles about stellar nucleosynthesis (see `https://en.wikipedia.org/wiki/Stellar_nucleosynthesis`) and abundances of the chemical elements (see `https://en.wikipedia.org/wiki/Abundance_of_the_chemical_elements`).

There are several contributions to nucleosynthesis in the standard model. The first contribution comes from Big Bang (BBN), second contribution from supernova nucleosynthesis and the third from cosmic ray spallation.

4.1.1 Nuclear fusion during Big Bang

Big Bang nucleosynthesis (BBN) lasting from 10 seconds to 20 minutes after Big Bang produced stable light elements up to $7Li$. Also unstable ^7Be decaying to ^7Li and ^3H decaying to ^3He was produced.

1. ^1H ja ^4He nuclei dominate and the remaining nuclei give only fraction of order .01 per cent. The value of n/p ratio at the moment when $n \leftrightarrow p$ transformations ceased to occur is decisive since all neutrons and protons, which could recombine to ^4He did so after this moment. For $n/p \simeq 1/7$ a correct relative abundance for ^4He is obtained. This can be understood quite concretely: 4 of 12+4 nucleons could combine to ^4He and did so. For ^4He particle number fraction was $1/13 \simeq 7.7$ per cent and mass fraction 25 percent. For protons the particle number fraction was $12/13 \simeq 92.3$ and mass fraction 75 percent.

2. BBN produces also deuterium. The amount of D produced is highly sensitive to the initial conditions since deuterium is only marginally stable unlike ^4He . Part of D could have combined to ^4He. There is sensitivity to the baryon density and to the expansion rate of the Universe determined by the total mass density. The observed finite amount of D implies finite age of Universe unless there are some other mechanisms producing deuterium.

3. If the Universe consisted of protons and neutrons only during fusion to ^4He, the density of nucleons would have been be so high that all D would have burned to ^4He. Nuclear fusion (temperature should be at critical range to not produce deuterium) in stars cannot produce deuterium and the production by nuclear fission is also difficult. This has forces to assume the presence of dark matter at the time of BBN. Also dark energy could be in question. Cosmic ray spallation was proposed as source of D but failed to explain its abundance. It is however suggested do explain the abundances of the other elements.

4. Also small fractions of ^7Li and ^7Be were produced but no heavier elements was produced. The reason was the absence of stable nuclei with 8 or 5 nucleons. This severely limited the

amounts of ^7Li and ^9Be (unstable) nuclei produced. In stars triple alpha process produces carbon but the rate is so slow that it could not yield significant amount of carbon during BBN. In stars ^7Li burns to more massive nuclei.

There is however a problem. The abundances of ^7Li predicted by BBN and deduced from WMAP/Planck and the abundance derived from population II stars (see `https://en.wikipedia.org/wiki/Big_Bang_nucleosynthesis`). The predicted abundance is by a factor 2.2-4.3 higher than the observed one [C16] (see `http://adsabs.harvard.edu/abs/2008APS..NWS.B4003B`). The abstract of the article summarizes lithium anomalies.

The measured abundance for ^7Li is within a factor of two agreement with the standard Big Bang Nucleosynthesis (BBN) models, however for the more fragile ^6Li, its abundance has been observed at a level three orders of magnitude above those predicted by standard BBN model. These discrepancies are known as the Lithium Anomaly. The standard BBN model predicts an abundance ratio for $[^7Li/^6Li]$ of the order of a 1000 or greater. Precise measurements of isotopic ratio indicate that $[^7Li/^6Li] = 12.3$. This discrepancy is the Strong Lithium Anomaly. The measured abundance $[^7Li/^1H] = (1.5+0.3)\times 10^{10}$ is a factor of two lower than the abundance $[^7Li/^1H] = (3.82+0.70)\times 10^{-10}$ predicted by the standard BBN calculations, and this discrepancy is the Weak Lithium Anomaly. A quick review will be done of the reactions that have been included in the BBN calculations of Lithium-6 abundance. I will discuss an experiment to address the Lithium Anomaly, via the ^7Li (^3He, ^4He)^6Li reaction using the TACTIC detector at TRIUMF.

5. Some old stars are found to contain boron, which suggests that also Boron was produced during BBN. Standard BBN does not allow it but the fact that resonant alpha capture by ^7Li producing Boron has been observed [C15] suggests that Boron is actually produced during BBN.

4.1.2 Stellar nucleosynthesis

Elements lighter than Fe are formed by stellar nucleosynthesis (`https://en.wikipedia.org/wiki/Stellar_nucleosynthesis`). Binding energy begins to decrease after Fe and the buildup of these nuclei requires energy and it seems that stellar fusion cannot provide it.

1. Proton-proton chain reaction (`https://en.wikipedia.org/wiki/Protonproton_chain_reaction`) produces ^3He and to ^3He:s fuse to $^4He+2p$. The direct fusion of ^3He or ^3H to ^4He is would require energy so that fusion of two ^3He:s is necessary. Both hydrogen and ^3He nuclei are depleted.

2. Lithium burning (see `https://en.wikipedia.org/wiki/Lithium_burning`) depletes lithium and ^4He is generated. The observed lithium should come from Big Bang in standard cosmology. The abundance of ^7Li is by a factor 2/3 smaller than the predicted abundance whereas the abundance of ^6Li is too high by several orders of magnitude [C16].

3. Triple alpha process (see `https://en.wikipedia.org/wiki/Triple-alpha_process`) was discovered by Hoyle. Hoyle started from the empirical fact that carbon must have been produced abundantly. On the other, hand there seemed to be a bottleneck preventing production of ^{12}C by alpha capture. The fusion of two ^4He to unstable ^8Be requires at least the energy of 91.8 keV and occurs slightly faster than its reversal after hydrogen has transformed to ^4He. To produce C another fusion is needed and since triple alpha process is unlikely, it would take long time to produce the needed amount of carbon. Hoyle made a brave hypothesis: carbon must have a resonant state with energy very near to that of $^8Be+^4He$. If this is the case the process can proceed resonantly. It turned out that this hypothesis was correct!

4. Once C is generated alpha process (see `https://en.wikipedia.org/wiki/Alpha_process`) adds ^4He repeatedly and builds heavier nuclei up to Fe. The first heavy nucleus is ^{16}O.

5. CNO cycle converts four protons to helium in 4 steps. It starts from C and proceeds by fusion proton with the heavier C, N, or O nucleus and by beta decays and ends with alpha decay of O to C as the last step (see `https://en.wikipedia.org/wiki/CNO_cycle`).

6. Other important burning processes take lace in stars considerably heavier than Sun are carbon burning (see https://en.wikipedia.org/wiki/Carbon-burning_process), oxygen burning (see https://en.wikipedia.org/wiki/Oxygen-burning_process), and neon burning: (see https://en.wikipedia.org/wiki/Neon-burning_process).

4.1.3 Supernova fusion

Stellar nucleosynthesis leads to explosive oxygen burning and silicon burning the elements silicon, sulfur, chlorine, argon, sodium, potassium, calcium, scandium, titanium and iron peak elements: vanadium, chromium, manganese, iron, cobalt, and nickel. These elements known as "primary elements" can be fused from pure hydrogen and helium in massive stars. As a result of their ejection from supernovae, their abundances increase within the interstellar medium.

Elements heavier than nickel are believed to be created primarily by supernova nucleosynthesis (see https://en.wikipedia.org/wiki/Supernova_nucleosynthesis). The processes involved are slow neutron capture (s-process, see https://en.wikipedia.org/wiki/S-process, fast neutron capture (r-process, see https://en.wikipedia.org/wiki/R-process), and fast proton capture (r-p-process, see https://en.wikipedia.org/wiki/Rp-process). The most important process is r-process. The resulting elements are much less abundant than the primary chemical elements. Other processes thought to be responsible for some of the nucleosynthesis of under-abundant heavy elements, notably a proton capture process known as the rp-process and a photodisintegration process known as the gamma (or p) process. The latter would synthesize the lightest, most neutron-poor, isotopes of the heavy elements.

Interestingly (and rather alarmingly!), the only modern nearby supernova SN1987A, has not revealed r-process enrichments (see https://en.wikipedia.org/wiki/Supernova_nucleosynthesis). Modern thinking is that the r-process yield may be ejected from some supernovae but swallowed up in others as part of the residual neutron star or black hole.

Remark: The production of elements heavier than Fe might be a weak point of standard model. The proposed cold fusion by absorption of dark protons and possibly also neutrons is remarkably similar to the supernova fusion process. The failure to observe r-process in SN1987A raises the question whether the analog of supernova cold fusion could occur in interstellar space as cold fusion in TGD sense.

4.1.4 Cosmic ray spallation

Stellar nuclear fusion does not produce stable isotopes ^3He, ^7Li, ^9Be, ^{10}B, and ^{11}B. These isotopes have been however observed. The process known as cosmic ray spallation (CRB, see https://en.wikipedia.org/wiki/Cosmic_ray_spallation) has been proposed as a mechanism producing these nuclei. The collision of highly energetic charged cosmic ray induces nuclear fission to larger number of lighter fragments and in this manner gives rise to a synthesis of lighter elements. CRB would also explain the presence of a beta-unstable nuclei such as ^7Be in environment with lifetime of 53.6 d. Also tritium and isotopes of aluminium, carbon (^{14}C), chlorine, iodine and neon are formed in CRB.

Remark: Cold fusion in TGD sense does not produce beta-instable elements and this might allow to disentangle the predictions of CRB model from those of cold fusion model.

4.2 Could cold fusion help?

TGD based model of cold fusion [C11, C12] relies on two new physics elements: the hierarchy of Planck constants and the notion of magnetic body. Cold fusion would occur in two steps. First dark nuclei (large $h_{eff} = n \times h$) with much lower binding energy than ordinary nuclei are formed at magnetic flux tubes possibly carrying monopole flux, and are transformed by dark beta decay and W exchange to beta-stable dark nuclei. These nuclei can leak out the system along magnetic flux tubes but in presence of metallic surfaces in negative potential can suffer a phase transition to ordinary nuclei and liberate nuclear binding energy.

An essential condition is that the dark protons can decay to neutrons rapidly enough by exchanges of dark weak bosons effectively massless below atomic length scale. Also beta decays in which dark W boson decays to dark electron and neutrino can be considered. This allows to overcome the Coulomb wall and explains why final state nuclei are stable and the decay to ordinary nuclei does not yield only protons.

The model is motivated by several experimental findings about cold fusion.

1. Leif Holmlid has introduced the notion of fusion induced by Coulomb explosion of ultradense deuterium (see popular article `http://tinyurl.com/nbephxb`). The slides of the talk by Sweinn Olaffsson (see `http://tempid.altervista.org/SRI.pdf`) give a more technical representation about the subject. Also ultradense variant of hydrogen can be considered. The article *Laser-driven nuclear fusion D+D in ultra-dense deuterium: MeV particles formed without ignition* (see `http://tinyurl.com/pm56kk3`) gives a more detailed representation about the idea [C3]. The TGD based model for the findings assumes that laser pulse induces a compression in longitudinal direction and formation of large h_{eff} phase on magnetic flux tube in the direction of laser pulse.

2. The TGD inspired model [L1] for what Pollack [L1] calls the fourth phase of water involving negatively charged exclusion zones (EZs) plays central role in TGD inspired quantum biology [L3] and also serve as the starting point for the model of cold fusion. The basic idea is that the protons disappearing from EZ become dark protons at dark magnetic flux tubes and form sequences identifiable as dark nuclei [K7]. Ordinary nuclei would result in the phase transition reducing Planck constant to its ordinary value.

3. The earlier TGD based model [K7] modifying the cold fusion model of Widom and Larsen [C2] (`http://newenergytimes.com/v2/sr/WL/WLTheory.shtml`) provides also an important ingredient. In Widom-Larsen model weak boson exchange transforming the proton approaching the target nucleus to neutron allows to overcome Coulomb wall. The extremely slow rate for weak boson exchange is the weak point of the model.

   This exchange is fast if weak bosons are dark and thus effectively massless in the length scale considered: this length scale would be $h_{eff}/h = n$-multiple of weak scale and could be as long as 100 microns but atomic length scale is in principle enough. In the recent model W emission and W exchanges would transform dark proton sequences to dark nuclei containing also neutrons so that Coulomb instability could be overcome. Dark nucleosynthesis in living matter (biofusion has been reported to occur) would also explain why parity breaking effects are large in cell scale.

4. The so called Brown's gas [H2] regarded by skeptics as pseudoscience (see `https://en.wikipedia.org/wiki/Oxyhydrogen`) can be interpreted in terms dark fusion products leaking out of the system along flux tubes. Both the claimed ability of Brown's gas to melt metals although itself at temperature of order 100 Celsius and the claims of the article summarizing the findings of LeClair (see `https://nanospireinc.com/Fusion.html`) suggest that the presence of metallic surface could prevent the dark nuclei from escaping by inducing a phase transition reducing the value of Planck constant to its ordinary value. This can be understood if the metallic surface is negatively charged and attracts the positively charge dark nuclei at the flux tubes and forces the phase transition to occur.

   The phase transition would liberate an energy, which is essentially the total nuclear binding energy (if the dark nuclear binding energy scales like $1/h_{eff}$ it would be rather small in nuclear energy scale) and thus larger than liberated in ordinary nuclear fusion or fission. LeClair also claims that the nuclei produced are beta stable and the spectrum is same as for the nuclei produced by supernova nucleosynthesis: if true this would suggest that capture of neutrons or protons would be the basic mechanism. It is easy to challenge LeClair's claims and this has been done but they seem to conform with the predictions of the TGD model: I realized this only when learning about what supernova nucleosynthesis is. Also a recent very strange finding about spectrum of Ni isotopes produced in E-Cat reactor conform with the predictions of TGD based model [L2].

The basic prediction is that the process cannot produce beta-unstable isotopes, which should be thus produced by cosmic ray spallation. Dark cold fusion might provide insights to the problems of standard model of nucleosynthesis.

Let us consider first a model of nucleosynthesis in which the binding energies of dark nuclei are obtained by a simple universal scaling from the ordinary binding energies so that kinematical constrains remain the same as in ordinary nuclear fusion. Let us also assume that absorption of two dark protons by same dark nucleus to give dark nuclear string is a slow process.

With these assumptions the absorption of dark protons (and possibly also dark neutrons) would be a process very much analogous to r-p process but restricted to occur only between beta stable isotopes and involving rapid stabilizing dark beta decays. Also the analogs of s- and r-processes a possible but would not happen if the formation of EZs is behind the cold fusion.

In the following considerations I have used the excellent tables of an old text book "Nuclear Physics" of Robert Howard about nuclear physics [C17]. One can certainly find from web more modern representations but I have somehow become attached to this nice old-fashioned book.

1. Interstellar dark nuclear fusion involving dark matter in TGD sense could generate deuterium, ^3He, and ^4He from hydrogen. The ordinary fusion of proton and ^4He to ^5He via beta decay or to ^5Li does not occur spontaneously. Whether the dark counterparts of these processes are possible depends on the binding energy of dark ^4He. If one believes in ultra naive scaling of binding energies then dark variants of these processes could not take place and one would have only the sequence $H \rightarrow D \rightarrow ^3He \rightarrow ^4He$. The chain stops at ^4He and only the densities of lightest elements up to ^4He would be affected.

2. D abundance is predicted to be too low unless the presence of dark matter is assumed during BBN: the reason is that D nuclei fuse to $4He$ nuclei. Dark energy can can do same trick as dark matter and TGD indeed predicts its presence in the early cosmology. One can of course consider also a scenario without primordial dark energy/matter. This would require that there is a mechanism producing deuterium. Cosmic ray spallation can generate ^3He, Be, and B but not D (because of its marginal stability). Here interstellar cold fusion could come in rescue. This option does not look plausible to me.

3. Traces of boron have been found in some old stars (see `https://en.wikipedia.org/wiki/Big_Bang_nucleosynthesis`). This might be called boron anomaly. One can wonder whether high nucleon densities could have made the alpha captures $^6Li +^4 He \rightarrow ^{10}B$ and $^7Li +^4 He \rightarrow ^{17}B$ possible and produced boron. Resonant alpha capture $^7Li(\alpha, \gamma)$ is indeed known to take place [C5] (see `http://tinyurl.com/z6clc79`) and one can wonder whether it could take place during BBN. Mechanism would be a copy of the mechanism proposed by Hoyle to produced carbon.

4. Lithium anomaly involves actually two anomalies. The observed ^7Li abundance is lower than predicted and the observed $^6Li/^7Li$ ratio is higher than predicted by orders of magnitude. If the resonant alpha capture by ^7Li giving rise to B takes place early cosmology it could have reduced ^7Li abundance already at that time. The absence of resonant alpha capture for ^6Li could in turn explain its recent over abundance with respect to ^7Li as present already primordially.

5. How cold fusion could affect the BBN abundances of lithium, B and Be? In the pessimistic scenario (exact scaling of binding energies) one would have only single step $^6Li \rightarrow ^7Li$. Some fraction of ^6Li would transformed to ^7Li. Cosmic ray spallation would be needed to produce B and Be. The presence of beta unstable isotopes with relatively short life time (such as tritium) gives support for the occurrence of cosmic ray spallation since the presence of tritium cannot be explained by dark cold fusion.

6. The sequence $^9Be \rightarrow ^{10}B \rightarrow ^{11}B \rightarrow ^{12}C \rightarrow ^{13}C \rightarrow ^{14}N \rightarrow ^{15} ...^{36}A$ of beta stable nuclei would be very long and mean flow from low mass numbers to higher ones. Also the sequence of beta stable nuclei starting from ^{39}K would extend to ^{64}Zn.

The above sketchy model involves strong simplifying assumptions, which can be criticized.

1. The naive scaling of binding energy could be of course too strong an assumption. Also the assumption that two subsequent absorptions of dark proton has a low rate is only the first guess. For instance, the steps $^4He \rightarrow ^6Li$ and $^7Li \rightarrow ^9Be$ would require fusion of 2 protons

to already existing nucleus. Dark variants of beta un-stable isotopes ^5He, ^5Li and ^nBe, $n = 6, 7, 8$ could appear as dark intermediate states if they are stable enough against dark variants of strong interactions the rates for the $n = 2$ steps would be higher.

2. One can consider also the possibility that the capture of ^4He nuclei transforming to dark nuclei is involved so that one would obtain nuclei consisting of ^4He nuclei plus some protons and neutrons. As a matter of fact, nuclear string model [K7] assumes that there is a kind of fractal structure involved in which ^4He nuclear strings become building bricks of higher level nuclear strings (flux tubes inside flux tubes). ^4He nuclei could be first generated by dark fusion if the formation of EZs is the basic mechanism. This would bring in dark variants of the basic mechanisms of stellar nuclear fusion and suggests fusion product spectrum probably resembling that produced in stellar nuclear fusion inside stars. It would also allow resonant transformation of ^7Li to ^{10}B and in this manner might help to understand Lithium anomalies.

One can challenge also the supernova fusion believed to produce elements heavier than Fe. r- and s-processes involving absorption of neutron and rp-process involving absorption of proton in general require energy in the case of nuclei heavier than Fe and the energy liberated in supernova collapse could provide this energy. An alternative mechanism is by interstellar dark fusion involving absorption of dark protons and also neutrons by heavy nucleus. One can consider the possibility that no external energy feed is needed. At least the energy feed would be by about factor 10^{-5} smaller if the proposed model is qualitatively correct. The rapidly occurring beta decays would allow only beta stable outcomes and this could serve as a signature of the process.

There is evidence that the abundances of metals in the early universe for redshifts 2-3 are lower than predicted [C15]. For instance, for one particular case with $z = 2.7276$ for which rather reliable data exist, the abundances of N, Mn, Fe, Ni are below predicted. Same is true for O, Mg, Si, P, and S as figure 4 of [C15] (see `http://arxiv.org/pdf/astro-ph/0603066.pdf`) demonstrates. N abundance is especially low in this example. The proposed cold fusion mechanism would induce the flow of nuclei to higher mass numbers and increase the abundances at later times. If the density of protons was larger at the end of BBN period as absence of dark matter at that time demands, dark cold fusion could have induced a flow of baryon number to the direction of higher mass numbers.

REFERENCES

Particle and Nuclear Physics

[C1] Summaries of Widom-Larsen theory. Available at: `http://newenergytimes.com/v2/sr/WL/WLTheory.shtml#summary`.

[C2] Widom-Larsen LENR Theory Portal. Available at: `http://newenergytimes.com/v2/sr/WL/WLTheory.shtml`.

[C3] Holmlid L Badiei S, Patrik PU. Laser-driven nuclear fusion D+D in ultra-dense deuterium: MeV particles formed without ignition. *Laser and Particle Beams.* `http://tinyurl.com/pm56kk3.`, 28(02):313–317, 2012.

[C4] Choi JH et al. Observation of energy and baseline dependent reactor antineutrino disappearance in the reno experiment. Available at: `http://arxiv.org/pdf/1511.05849v2.pdf`, 2015.

[C5] G. Hardie et al. Resonant alpha capture by ^{7}Be and ^{7}Li. *Phys. Rev. C.* `http://tinyurl.com/z6clc79`, 29(4):1199–1206, 1984.

[C6] Jenkins JH et al. Evidence for Correlations Between Nuclear Decay Rates and Earth-Sun Distance. Available at: `http://arxiv.org/abs/0808.3283`, 2008.

[C7] Rolfs C et al. First hints on a change of the ^{2}2Na beta decay half-life in the metal Pd. *Eur Phys J A*, 28, 2006.

[C8] Rolfs C et al. High-Z electron screening, the cases ^{50}V(p,n)^{50}. *Eur Phys J A*, 28, 2006.

[C9] Shnoll SE et al. Realization of discrete states during fluctuations in macroscopic processes. *Usp Fis Nauk*, 41(10):1025–1035, 1998.

[C10] Taleyarkhan RP et al. Nuclear Emissions During Self-Nucleated Acoustic Cavitation. Available at: `http://adsabs.harvard.edu/abs/2006PhRvL..96c4301T`, 2006.

[C11] Hawkins M Fleischmann M, Pons S. Electrochemically induced nuclear fusion of deuterium. *J Electroanal Chem*, 261:263, 1989.

[C12] Rossi A Focardi S. A new energy source from nuclear fusion. Available at: `http://tinyurl.com/ohal8cd`, 2011.

[C13] Fischbach E Jenkins JH. Perturbation of Nuclear Decay Rates During the Solar Flare of 13 December 2006. Available at: `http://arxiv.org/abs/astro-ph/0808.3156`, 2008.

[C14] Holmlid L and Kotzias B. Phase transition temperatures of 405-725 K in superfluid ultra-dense hydrogen clusters on metal surfaces. *AIP Advances*. Available at: `http://tinyurl.com/hxbvfc7`, 6(4), 2016.

[C15] Pettini M. Chemical elements at high and low redshifts. Available at: `http://arxiv.org/pdf/astro-ph/0603066.pdf`, 2006.

[C16] Bruskiewich P. The Strong and Weak Lithium Anomaly in BBN. In *APS Northwest Section Meeting Abstracts*. `http://adsabs.harvard.edu/abs/2008APS..NWS.B4003B`, 2008.

[C17] Howard R. *Nuclear Physics*. Wadsworth Publishing Company, Inc.., 1963.

Fringe Physics

[H1] The Home of Primordial Energy. Available at: `http://www.depalma.pair.com`.

[H2] King MB. Water Electrolyzers and the Zero-Point Energy. *Phys Procedia* . Available at: `http://www.sciencedirect.com/science/journal/18753892`, 20:335–445, 2011.

Biology

[I1] The Fourth Phase of Water : Dr. Gerald Pollack at TEDxGuelphU. Available at: `https://www.youtube.com/watch?v=i-T7tCMUDXU`, 2014.

Books related to TGD

[K1] Pitkänen M. About Strange Effects Related to Rotating Magnetic Systems . In *TGD and Fringe Physics*. Onlinebook. Available at: `http://tgdtheory.fi/public_html/freenergy/freenergy.html#Faraday`, 2006.

[K2] Pitkänen M. Dark Forces and Living Matter. In *Hyper-finite Factors and Dark Matter Hierarchy*. Onlinebook. Available at: `http://tgdtheory.fi/public_html/neuplanck/neuplanck.html#darkforces`, 2006.

[K3] Pitkänen M. Dark Nuclear Physics and Condensed Matter. In *Hyper-finite Factors and Dark Matter Hierarchy*. Onlinebook. Available at: `http://tgdtheory.fi/public_html/neuplanck/neuplanck.html#exonuclear`, 2006.

[K4] Pitkänen M. Homeopathy in Many-Sheeted Space-Time. In *Bio-Systems as Conscious Holograms*. Onlinebook. Available at: `http://tgdtheory.fi/public_html/hologram/hologram.html#homeoc`, 2006.

[K5] Pitkänen M. Massless states and particle massivation. In *p-Adic Physics*. Onlinebook. Available at: http://tgdtheory.fi/public_html/padphys/padphys.html#mless, 2006.

[K6] Pitkänen M. Negentropy Maximization Principle. In *TGD Inspired Theory of Consciousness*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdconsc/tgdconsc.html#nmpc, 2006.

[K7] Pitkänen M. Nuclear String Hypothesis. In *Hyper-finite Factors and Dark Matter Hierarchy*. Onlinebook. Available at: http://tgdtheory.fi/public_html/neuplanck/neuplanck.html#nuclstring, 2006.

[K8] Pitkänen M. Quantum Model for Bio-Superconductivity: I. In *TGD and EEG*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdeeg/tgdeeg.html#biosupercondI, 2006.

[K9] Pitkänen M. Quantum Model for Bio-Superconductivity: II. In *TGD and EEG*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdeeg/tgdeeg.html#biosupercondII, 2006.

[K10] Pitkänen M. Quantum Model for Nerve Pulse. In *TGD and EEG*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdeeg/tgdeeg.html#pulse, 2006.

[K11] Pitkänen M. TGD and Nuclear Physics. In *Hyper-finite Factors and Dark Matter Hierarchy*. Onlinebook. Available at: http://tgdtheory.fi/public_html/neuplanck/neuplanck.html#padnucl, 2006.

[K12] Pitkänen M. Quantum Mind, Magnetic Body, and Biological Body. In *TGD based view about living matter and remote mental interactions*. Onlinebook. Available at: http://tgdtheory.fi/public_html/tgdlian/tgdlian.html#lianPB, 2012.

[K13] Pitkänen M. *p-Adic length Scale Hypothesis*. Onlinebook. Available at: http://tgdtheory.fi/public_html/padphys/padphys.html, 2013.

[K14] Pitkänen M. More Precise TGD View about Quantum Biology and Prebiotic Evolution. In *Genes and Memes*. Onlinebook. Available at: http://tgdtheory.fi/public_html/genememe/genememe.html#geesink, 2015.

Articles about TGD

[L1] Pitkänen M. Pollack's Findings about Fourth phase of Water : TGD View. Available at: http://tgdtheory.fi/public_html/articles/PollackYoutube.pdf, 2014.

[L2] Pitkänen M. Cold Fusion Again . Available at: http://tgdtheory.fi/public_html/articles/cfagain.pdf, 2015.

[L3] Pitkänen M. More Precise TGD Based View about Quantum Biology and Prebiotic Evolution. Available at: http://tgdtheory.fi/public_html/articles/geesink.pdf, 2015.

[L4] Pitkänen M. Tewari's space-energy generator two decades later . Available at: http://tgdtheory.fi/public_html/articles/tewari.pdf, 2015.

[L5] Pitkänen M. TGD based model for anesthetic action. Available at: http://tgdtheory.fi/public_html/articles/anesthetes.pdf, 2015.

[L6] Pitkänen M. Reactor antineutrino anomaly as indication for new nuclear physics predicted by TGD . Available at: http://tgdtheory.fi/public_html/articles/antinuanomaly.pdf, 2016.