Exploration

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 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 chapter 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.

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.

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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 [10, 11, 14, 17, 19].

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 [19] 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 [11] 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 [11] of Widom-Larsen model [2] (`http://newenergytimes.com/v2/sr/WL/WLTheory.shtml`) with the model [19] inspired by the TGD inspired model of Pollack's fourth phase of water [8] using as input data findings from laser pulse induced cold fusion discovered by Leif Holmlid and collaborators [3] (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 [13, 18] 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 [2] (`http://newenergytimes.com/v2/sr/WL/WLTheory.shtml`) have proposed a theory of cold fusion (LENR) [1], 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 [14]. 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 [11] could be that weak interactions are mediated by dark variants of weak bosons such that weak scale is scaled up to atomic length scale by h_{eff}/h and weak bosons behave like massless bosos below atomic length scale. 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 in atomic length scale make weak gauge bosons effectively massless below the effective p-adic length scale 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 atomic length scale.

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 $k = 127 \to k = 107$, mass (size) would be scaled up (down) by a factor $2^{10} = 1024$ ($2^{-10} = 1/1024$). For $k = 127 \to k = 113$, 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 [19].

1. Pollack's exclusion zones (EZs) [8] are negatively charged regions of water giving rise to what Pollack calls the fourth phase of water. In TGD inspired model [10, 15, 16] [20] 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 [19].

   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 [7] is an example of this kind of system [**?**] [9]. 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 [3].

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 [3].

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 [14]. 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 $k = 127$ instead of $k = 137$ defining atomic length scale 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 ordinary 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 $r = 137$ this requires $h_{eff}/h = 2^{137-89)/2} = 2^{24} \simeq 1.6 \times 10^7$.

   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.

   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 [12, 14]. 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 suggest that if dark nuclei decay rapidly to ordinary ones, the emission of bunches of dark X rays dominates in this process.

2.5 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. $V = 2\mathrm{V/mm}$ 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 [**?**]PollackYoutube 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 [**?**]geesink 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 [**?**]nuclstring,homeoc. 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 [**?**]PonsF 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 [**?**]Rossi.

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 "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!

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 [**?**]nmpc defining the basic variational principle of TGD inspired theory of consciousness could be the general reason preventing this transformation [**?**]geesink. 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?

2.6 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 nuclear 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.

2.7 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 [5] the production of heat of with unknown origin in an electrolytic system using palladium metal as cathode 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 [6] 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 [11]. 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 [4] 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 [19] 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 [8] 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 unnecessary. 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.

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