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.

Contents

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 [K14, K10, K3, K2, L4].

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 [L4] 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 [L4] 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 [K17, K7] 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 [K10]. 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 $k = 127 \to k = 107$, 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 [L4].

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 [K11, K12, 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 [L4].

   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 [L5] [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 [K10]. 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 [K10]. 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 [C7] (see also `http://tinyurl.com/jaqrmdx`). The neutrino energies are around 5 MeV. For TGD inspired model see [L10].

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 [K10, K5]. 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 [L3]). 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 [L11] (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 supraphases 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 [K11, K12].

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 [K10] 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 $M_{127} = 2^{127} - 1$ [K7]. 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 [C10, C17, C13].

1. One possible TGD based explanation relies the nuclear string model [K10]. 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 [C11, C12], 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 [L4] 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 [K10, K5]. 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 [C15] 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 [C16].

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 [K8] defining the basic variational principle of TGD inspired theory of consciousness could be the general reason preventing this transformation [L4]. 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 stableandmust 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 [C15] 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 [C16] 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 [C14] 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 [L4] 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 supernova 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://tinyurl.com/jpzcs32`). 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 [K15] [L6]. 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 [K13]. 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 [C22] (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 [C20] 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 [C22].

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 [C15, C16] 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 [L4] 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 [K10]. Ordinary nuclei would result in the phase transition reducing Planck constant to its ordinary value.

3. The earlier TGD based model [K10] 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 [L3].

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 [C23]. 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 [C9] (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 $^4He \rightarrow^6 Li$ and $^7Li \rightarrow^9 Be$ 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 [K10] 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 [C20]. 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 [C20] (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.

4.3 What is the IQ of neutron star?

"*Humans and Supernova-Born Neutron Stars Have Similar Structures, Discover Scientists*" (see `http://tinyurl.com/y7qdeuba`) is the title of a popular article about the finding that neutron stars and eukaryotic (not only human) cells contain geometrically similar structures. In cells the cytoplasma between cell nucleus and cell membrane contains a complex highly folded membrane structure known as endoplasmic reticulum (ER). ER in turn contains stacks of evenly spaced sheets connected by helical ramps. They resemble multistory parking garages (see the illustration of the popular article). These structures are referred to as parking places for ribosomes, which are the machinery for the translation of mRNA to amino-acids. The size scale of these structures must be in the range 1-100 microns.

Computer simulations for neutron stars predict geometrically similar structures, whose size is however million times larger and therefore must be in the range of 1-100 meters.The soft condensed-matter physicist Greg Huber from U.C. Santa Barbara and nuclear physicist Charles Horowitz from Indiana University have worked together to explore the shapes [I2] (see `http://tinyurl.com/js9wavq` and `http://tinyurl.com/y72o474v`).

The physical principles leading to these structures look quite different. At nuclear physics side one has strong and electromagnetic interaction at microscopic level and in the model used they give rise to these geometric structures in macroscopic scales. In living matter the model assumes basically entropic forces and the basic variational principle is minimization of the free energy of the system - second law of thermodynamics for a system coupled to thermal bath at constant temperature. The proposal is that some deeper principle might be behind these intriguing structural similarities.

In TGD framework one is forced to challenge the basic principles behind these models as really fundamental principles and to consider deeper reasons for the geometric similarity. One ends up challenging even the belief that neutron stars are just dead matter.

1. In TGD framework space-time identified as 4-D surface in $H = M^4 \times CP_2$ is many-sheeted fractal structure. In TGD these structures are topological structures for the space-time itself as a 4-surface rather than for the distribution of the matter in topologically trivial almost empty Minkowski space.

   TGD space-time is also fractal characterized by the hierarchy of p-adic length scales assignable to primes near powers of two and to a hierarchy of Planck constants. Zero energy ontology (ZEO) predicts also a hierarchy of causal diamonds (CDs) as regions inside which space-time surfaces are located.

   The usual length scale reductionism is replaced with fractality and the fractality of the many-sheeted space-time could explain the structural similarity of structures with widely different size scales.

2. Dark matter is identified as a hierarchy of phases of ordinary matter labelled by the value $h_{eff} = n \times h$ of Planck constant. In adelic physics $h_{eff}/h = n$ has purely number theoretic interpretation as a measure for the complexity of extension of rationals - the hierarchy of dark matters would correspond to the hierarchy of these extensions and evolution corresponds to the increase of this complexity. It would be dark matter at the flux tubes of the magnetic body of the system that would make the system living and intelligent. This would be true for all systems, not only for those that we regard as living systems. Perhaps even neutron stars!

3. In adelic physics [L15] p-adic physics for various primes as physics of cognition and ordinary real number based physics are fused together. One has a hierarchy of adeles defined by extensions of rational numbers (not only algebraic extensions but by those using roots of e). The higher the complexity of the extension, the larger the number of common points shared by reals and p-adics: they correspond to space-time points with coordinates in an extension of rationals defining the adele. These common points are identified as cognitive representations,

something in the intersection of cognitive and sensory. The larger the number of points, the more complex the cognitive representations. Adeles define thus an evolutionary hierarchy.

The points of space-time surface defining the cognitive representation are excellent candidates for the carriers of fundamental fermions since many-fermion states allow interpretation in terms of a realization of Boolean algebra. If so then the complexity of the cognitive representation characterized by h_{eff}/h increases with the density of fundamental fermions! The larger the density of matter, the higher the intelligence of the system if this view is correct!

This view inspires interesting speculative questions.

1. In TGD inspired theory of consciousness conscious entities form a fractal hierarchy accompanying geometric fractal hierarchies. Could the analogies between neutron stars and cells be much deeper than merely geometric? Could neutron stars be super-intelligent systems possessing structures resembling those inside cells? What about TGD counterparts of black holes? For blackhole like structures the fermionic cognitive representation would contain even more information per volume than those for neutron star. Could blackholes be super-intelligences instead of mere cosmic trashbins?

   Living systems metabolize. The interpretation is that the metabolic energy allows to increase the value of h_{eff}/h and generate negentropic entanglement crucial for cognition. Also blackholes "eat" matter from their environment: is the reason the same as in the case of living cell?

   Living systems communicate using flux tubes connecting them and serving also as correlates of attention. In TGD frame flux tubes emanates from all physical systems, in particular stars and blackholes and mediate gravitational interactions. In fact, flux tubes replace wormholes in ER-EPR correspondence in TGD framework or more precisely: wormhole contacts replace flux tubes in GRT framework.

2. Could also blackhole like structures possess the analog of endoplasmic reticulum replacing the cell membrane with an entire network of membranes in the interior of cell? Interpretation as minimal surface is very natural in TGD framework. Could the predicted space-time sheet within blackhole like structure having Euclidian signature of the induced metric serve as the analog for cell nucleus? In fact, all systems - even elementary particles - possess the space-time sheet with Euclidian signature: this sheet is analogous to the line of Feynman diagram. Could the space-time sheet assignable to cell nucleus have Euclidian signature of the induced metric? Could cell membrane be analogous to blackhole horizon?

3. What abut genetic code? In TGD inspired biology genetic code could be realized already at the level of dark nuclear physics in terms of strings of dark protons: also ordinary nuclei are identified as strings of nucleons [K10]. Biochemical representation would be only a secondary representation and biochemistry would be a kind of shadow for the deeper dynamics of dark matter and magnetic flux tubes. Dark 3-proton states correspond naturally to DNA, RNA, tRNA and amino-acids and dark nuclei as polymers of these states [L7].

   Could neutron stars containing dark matter as dark nuclei indeed realize genetic code? This view about dark matter leads also to a proposal that the so called cold fusion could actually correspond to dark nucleosynthesis such that the resulting dark nuclei with rather small nuclear binding energy transform to ordinary nuclei and liberate most of the ordinary nuclear binding energy in this process [L14]. Could dark nucleosynthesis produce elements heavier than Fe and also part of the lighter elements outside stellar interiors. Could this happen also in the fusion of neutron stars to neutron star like entity as the recent simultaneous detection of gravitational waves (GW170817 event) and em radiation from this kind of fusion suggests [?] [L9].

4. How can one understand cell (or any system) as a trashbin like structure maximizing its entropy on one hand and as an intelligent system on one hand? This can make sense in TGD framework where the amount of conscious information, negentropy, is measured by the sum of p-adic variants of entanglement entropies and is negative(!) thanks to the properties of p-adic norm. Neutron stars, blackholes and cells would be entropic objects if one limits

the consideration to real sector of adeles but in p-adic sectors they would carry conscious information. The sum of real and p-adic entropies tends to be negative. Living cell would be very entropic object in real sense but very negentropic in p-adic sense: even more, the sum of negative p-adic negentropies associated with cognition in adelic physics would overcome this entropy [L2].

5 Neutron production from an arc current in gaseous hydrogen

I learned about nuclear physics anomaly new to me (actually the anomaly is 66 years old!) from an article of Norman and Dunning-Davies in Research Gate (see `http://tinyurl.com/y7jlhnx8`). Neutrons are produced from an arc current in hydrogen gas with a rate exceeding dramatically the rate predicted by the standard model of electroweak interactions, in which the production should occur through $e-+p \rightarrow n+\nu$ by weak boson exchange. The low electron energies make the process also kinematically impossible. Additional strange finding due to Borghi and Santilli is that the neutron production can in some cases be delayed by several hours. Furthermore, according to Santilli neutron production occurs only for hydrogen but not for heavier nuclei.

In the following I sum up the history of the anomaly following closely to the representation of Norman and Dunning-Davies [C21] (see `http://tinyurl.com/y7jlhnx8`): this article gives references and details and is strongly recommended. This includes the pioneering work of Sternglass in 1951, the experiments of Don Carlo Borghi in the late 1960s [C6], and the rather recent experiments of Ruggiero Santilli [C24] (see `http://tinyurl.com/y8nsh883`).

5.1 Experimental work

In the following the experimental support for neutron anomaly is summarized.

5.1.1 The pioneering experiment of Sternglass

The initial anomalously large production of neutrons using an current arc in hydrogen gas was performed by Earnest Sternglass in 1951 while completing his Ph.D. thesis at Cornell. He wrote to Einstein about his inexplicable results, which seemed to occur in conditions lacking sufficient energy to synthesize the neutrons that his experiments had indeed somehow apparently created. Although Einstein firmly advised that the results must be published even though they apparently contradicted standard theory, Sternglass refused due to the stultifying preponderance of contrary opinion and so his results were preemptively excluded under orthodox pressure within discipline leaving them unpublished. Edward Trounson, a physicist working at the Naval Ordnance Laboratory repeated the experiment and again gained successful results but they too, were not published.

One cannot avoid the question, what physics would look like today, if Sternglass had published or managed to publish his results. One must however remember that the first indications for cold fusion emerged also surprisingly early but did not receive any attention and that cold fusion researchers were for decades labelled as next to criminals. Maybe the extreme conservatism following the revolution in theoretical physics during the first decades of the previous century would have prevented his work to receive the attention that it would have deserved.

5.1.2 The experiments of Don Carlo Borghi

Italian priest-physicist Don Carlo Borghi in collaboration with experimentalists from the University of Recife, Brazil, claimed in the late 1960s to have achieved the laboratory synthesis of neutrons from protons and electrons. C. Borghi, C. Giori, and A. Dall'Olio published 1993 an article entitled "Experimental evidence of emission of neutrons from cold hydrogen plasma" in Yad. Fiz. 56 and Phys. At. Nucl. 56 (7) [C6].

Don Borghi's experiment was conducted via a cylindrical metallic chamber (called "klystron") filled up with a partially ionized hydrogen gas at a fraction of 1 bar pressure, traversed by an electric arc with about 500V and 10mA as well as by microwaves with 10^{10} Hz frequency. Note that the energies of electrons would be below .5 keV and non-relativistic. In the cylindrical exterior of the chamber the experimentalists placed various materials suitable to become radioactive when subjected to a neutron flux (such as gold, silver and others). Following exposures of the order of weeks, the experimentalists reported nuclear transmutations due to a claimed neutron flux of the order of 10^4 cps, apparently confirmed by beta emissions not present in the original material.

Don Borghi's claim remained un-noticed for decades due to its incompatibility with the prevailing view about weak interactions. The process $e^- + p \rightarrow n + \nu$ is also forbidden by conservation of energy unless the total cm energy of proton and the electron have energy larger than $\Delta E = m_n - m_p - m_e = 0.78$ MeV. This requires highly relativistic electrons. Also the cross section for the reaction proceeding by exchange of W boson is extremely small at low energies (about 10^{-20} barn: barn=10^{-28} m^2 represents the natural scale for cross section in nuclear physics). Some new physics must be involved if the effect is real. Situation is strongly reminiscent of cold fusion (or low energy nuclear reactions (LENR), which many main stream nuclear physicists still regard as a pseudoscience.

5.1.3 Santilli's experiments

Ruggero Santilli [C24] (see `http://tinyurl.com/y8nsh883`) replicated the experiments of Don Borghi. Santilli analyzes several alternative proposals explaining the anomalyn and suggests that new spin zero bound state of electron and proton with rest mass below the sum of proton and electron masses and absorbed by nuclei decaying then radioactively could explain the anomaly. The energy needed to overcome the kinematic barrier could come from the energy liberated by electric arc. The problem of the model is that it has no connection with standard model.

Both in the experiments of Don Carlo Borghi and those of Santilli, delayed neutron synthesis was *sometimes* observed. According to Santilli:

> *A first series of measurements was initiated with Klystron I on July 28,2006, at 2 p.m. Following flushing of air, the klystron was filled up with commercial grale hydrogen at 25 psi pressure. We first used detector PM1703GN to verify that the background radiations were solely consisting of photon counts of 5-7 μR/h without any neutron count; we delivered a DC electric arc at 27 V and 30 A (namely with power much bigger than that of the arc used in Don Borghi's tests...), at about 0.125" gap for about 3 s; we waited for one hour until the electrodes had cooled down, and then placed detector PM1703GN against the PVC cylinder. This resulted in the detection of photons at the rate of 10 - 15 μR/hr expected from the residual excitation of the tips of the electrodes, but no neutron count at all.*
>
> *However, about three hours following the test, detector PM1703GN entered into sonic and vibration alarms, specifically, for neutron detections off the instrument maximum of 99 cps at about 5' distance from the klystron while no anomalous photon emission was measured. The detector was moved outside the laboratory and the neutron counts returned to zero. The detector was then returned to the laboratory and we were surprised to see it entering again into sonic and vibrational alarms at about 5' away from the arc chamber with the neutron count off scale without appreciable detection of photons, at which point the laboratory was evacuated for safety.*
>
> *After waiting for 30 minutes (double neutron's lifetime), we were surprised to see detector PMl703GN go off scale again in neutron counts at a distance of 10' from the experimental set up, and the laboratory was closed for the day.*

5.2 TGD based model for the neutron anomaly

The basic problems to be solved are following.

1. What is the role of current arc and other triggering impulses (such as microwave radiation or pressure surge mentioned by Santilli): do they provide energy or do they have some other role?

2. Neutron production is kinematically impossible if weak interactions mediate it. Even if kinematically possible, weak interaction rates are quite too slow. The creation of intermediate

states via other than weak interactions would solve both problems. If weak interactions are involved with the creation of the intermediate states, how there rates can be so high?

3. What causes the strange delays in the production in some cases but now always? Why hydrogen gas is preferred?

The effect brings strongly in mind cold fusion (or LENR) - another process not allowed by standard model - for which TGD proposes a model [L3] in terms of generation of dark nuclei with non-standard value $h_{eff} = n \times h$ of Planck constant formed from dark proton sequences at magnetic flux tubes. The binding energy for these states replacing the scalar particle proposed by Santilli is supposed to be obtained by scaling the nuclear binding energy by $1h/h_{eff}$ and is much lower than for the ordinary nuclei. The proposal is that these nuclei decay to ordinary nuclei as the flux tubes attach to metallic targets with negative surface charge attracting positively charged magnetic flux tubes. The energy liberated would be of the essentially the ordinary nuclear binding energy. Note that the creation of dark proton sequences does not require weak interactions so that the basic objections are circumvented.

TGD explanation for anomalous neutron production could be the same for Tesla's findings [K16], for cold fusion [C3, L11] (see `http://tinyurl.com/j3csy53`), Pollack effect [L1] [L1] and for the anomalous production of neutrons. Even electrolysis would involve in an essential manner Pollack effect and new physics.

Could this model explain the anomalous neutron production and its strange features?

1. Why electric arc, pressure surge, or microwave radiation would be needed? Dark phases are formed at quantum criticality [K19] and give rise to the characteristic long range correlations via quantum entanglement made possible by large $h_{eff} = n \times h$. The presence of electron arc occurring as di-electric breakdown is indeed a critical phenomenon Already Tesla discovered strange phenomena in his studies of arc discharges but his discoveries were forgotten by mainstream.

   Also energy feed might be involved. Quite generally, in TGD inspired quantum biology generation of dark states requires energy feed and the role of metabolic energy is to excite dark states. For instance, dark atoms have smaller binding energy and the energies of cyclotron states increase with h_{eff}/h. For instance, part of microwave photons could be dark and have much higher energy than otherwise.

   Could the production of dark proton sequences at magnetic flux tubes be all that is needed so that the possible dark variant of the reaction $e^- + p \rightarrow n + \nu$ would not be needed at all?

2. If also weak bosons appear as dark variants, their Compton length is scaled up accordingly and in scales shorter than the Compton length, they behave effectively like massless particles and weak interactions become as strong as electromagnetic interactions. This would make possible a rapid decay of dark proton sequences at magnetic flux tubes to beta stable dark isotopes via $p \rightarrow n + e^+ + \nu$: there is indeed evidence that cold fusion produces only beta stable isotopes. Neutrons would be produced in the decays of the dark nuclei to ordinary nuclei liberating nuclear binding energy. Note however that TGD allows also to consider p-adically scaled variants of weak bosons with much smaller mass scale possible important in biology [K6], and one cannot exclude them from consideration.

3. The reaction $e^- + p \rightarrow n + \nu$ is not necessary in the model. One can however ask, whether there could exist a mechanism making the dark reaction $e^- + p \rightarrow n + \nu$ kinematically possible. If the scale of dark nuclear binding energy is strongly reduced, also $p \rightarrow n + e^+ + \nu$ in dark nuclei would become kinematically impossible (in ordinary nuclei nuclear binding energy makes n effectively lighter than p).

   TGD based model for nuclei as strings of nucleons [K10] [L3] connected by neutral or charged (possibly colored) mesonlike bonds with quark and antiquark at its ends could resolve this problem (if one wants to see it as a problem). One could have exotic nuclei in which proton plus negatively charged bond could effectively behave like neutron. Dark weak interactions would take place for neutral bonds between protons and reduce the charge of the bond from $q = 0$ to $q = -1$ and transform p to effective n. This was assumed also in the model of dark nuclei and also in the model of ordinary nuclei and predicts large number of exotic states. One can of course ask, whether the nuclear neutrons are actually pairs of proton and negatively charged bond.

4. What about the delays in neutron production occurring in some cases? Why not always? In the situations, when there is a delay in neutron production, the dark nuclei could have rotated around magnetic flux tubes of the magnetic body (MB) of the system before entering to the metal target, one would have a delayed production.

5. Why would hydrogen be preferred? Why for instance, deuteron and heavier isotopes containing neutrons would not form dark proton sequences at magnetic flux tubes. Why would be the probability for the transformation of say D=pn to its dark variant be very small?

   If the binding energy of dark nuclei per nucleon is several orders of magnitude smaller than for ordinary nuclei, the explanation is obvious. The ordinary nuclear binding energy is much higher than the dark binding energy so that only the sequences of dark protons can form dark nuclei. The first guess made in [L3] is that the binding energy is analogous to Coulomb energy and thus inversely proportional to the size scale of dark nucleus scaling like h/h_{eff}. One can however ask why D with ordinary size could not serve as sub-unit.

6 Cold fusion, low energy nuclear reactions, or dark nuclear synthesis?

Steven Krivit has written three books or one book in three parts [C26, C25, C27] - as you wish - about cold fusion (shortly CF in the sequel) - or low energy nuclear reaction (LENR) - which is the prevailing term nowadays and preferred by Krivit. The term "cold fusion" can be defended only by historical reasons: the process cannot be cold fusion. LENR relies on Widom-Larsen model (WL) trying to explain the observations using only the existing nuclear and weak interaction physics. Whether LENR is here to stay is still an open question. TGD suggests that even this interpretation is not appropriate: the nuclear physics involved would be dark and associated with $h_{eff} = n \times h$ phases of ordinary matter having identification as dark matter. Even the term "nuclear transmutation" would be challenged in TGD framework and "dark nuclear synthesis" looks a more appropriate term.

6.1 General comments

The books were a very pleasant surprise for many reasons, and I have been able to develop my own earlier overall view by adding important details and missing pieces and allowing to understand the relationship to Widom-Larsen model (WL).

6.1.1 What the books are about?

There are three books.

"Hacking the atom: Explorations in Nuclear Research, vol I" (see `http://tinyurl.com/yb2zxpmy`) considers the developments between 1990-2006. The first key theme is the tension between two competing interpretations. On one hand, the interpretation as CF involving necessarily new physics besides ordinary nuclear fusion and plagued by a direct contradiction with the expected signatures of fusion processes, in particular those of $D + D \rightarrow^4 He$. On the other hand, the interpretation as LENR in the framework of WL in which no new physics is assumed and neutrons and weak interactions are in a key role.

Second key theme is the tension between two competing research strategies.

(a) The first strategy tried to demonstrate convincingly that heat is produced in the process - commercial applications was the basic goal. This led to many premature declarations about solution of energy problems within few years and provided excellent weapons for the academic world opposing cold fusion on basis of textbook wisdom.

(b) Second strategy studied the reaction products and demonstrated convincingly that nuclear transmutations (isotopic shifts) took place. This aspect did not receive attention in public and the attempts to ridiculize have directed attention to the first approach and to the use of the term “cold fusion”.

According to Krivit, CF era ended around 2006, when Widom and Larsen proposed their model in which LENR would be the mechanism [C30, C2, C1, C28, C29]. Widom-Larsen model (WL) can be however criticized for some un-natural looking assumptions: electron is required to have renormalized mass considerably higher than the real mass; the neutrons initiating nuclear reactions are assumed to have ultralow energies below thermal energy of target nuclei. This requires electron mass to be larger but extremely near to neutron-proton mass difference. The gamma rays produced in the process are assumed to transform to infrared radiation.

To my view, WL is not the end of the story. New physics is required. For instance, the work of professor Holmlid and his team [C3, L11] has provided new fascinating insights to what might be the mechanism of what has been called nuclear transmutations.

“Fusion Fiasco: Explorations in Nuclear Research, vol II” (see `http://tinyurl.com/ybtvwlyz`) discusses the developments during 1989 when cold fusion was discovered by Fleischman and Pons [C15] and interpreted as CF. It soon turned out that the interpretation has deep problems and CF got the label of pseudoscience.

“Lost History: Explorations in Nuclear Research, vol III” (see `http://tinyurl.com/ybxrsvqk`) tells about surprisingly similar sequence of discoveries, which has been cleaned away from history books of science because it did not fit with the emerging view about nuclear physics and condensed matter physics as completely separate disciplines. Although I had seen some remarks about this era I had not not become aware what really happened. It seems that discoveries can be accepted only when the time is mature for them, and it is far from clear whether the time is ripe even now.

What I say in the sequel necessarily reflects my limitations as a dilettante in the field of LENR/CF. My interest on the topic has lasted for about two decades and comes from different sources: LENR/CF is an attractive application for the unification of fundamental interactions that I have developed for four decades now. This unification predicts a lot of new physics - not only in Planck length scale but in all length scales - and it is of course fascinating to try to understand LENR/CF in this framework.

For instance, while reading the book, I realized that my own references to the literature have been somewhat random and not always appropriate. I do not have any systematic overall view about what has been done in the field: here the book makes wonderful service. It was a real surprise to find that first evidence for transmutation/isotope shifts emerged already for about century ago and also how soon isotope shifts were re-discovered after Pons-Fleischman discovery [C15]. The insistence on $D + D \rightarrow^4 He$ fusion model remains for an outsider as mysterious as the refusal of mainstream nuclear physicists to consider the possibility of new nuclear physics. One new valuable bit of information was the evidence that it is the cathode material that transforms to the isotope shifted nuclei: this helped to develop my own model in more detail.

Remark: A comment concerning the terminology. I agree with the author that cold fusion is not a precise or even correct term. I have myself taken CF as nothing more than a letter sequence and defended this practice to myself as a historical convention. My conviction is that the phenomenon in question is not a nuclear fusion but I am not at all convinced that it is LENR either. Dark nucleosynthesis is my won proposal.

6.1.2 What did I learn from the books?

Needless to say, the books are extremely interesting, for both layman and scientist - say physicist or chemist, or anyone involved in developing new energy technologies. The books provide a very thorough view about the history of the subject. There is also an extensive list of references to the literature. Since I am not an experimentalist and feel myself a dilettante in this field as a theoretician, I am unable to check the correctness and reliability of the data represented. In any case, the overall view is consistent with what I have learned about the situation during years. My opinion about WL is however different.

I have been working with ideas related to CF/LENR (or nuclear transmutations) but found that books provided also completely new information and I became aware about some new critical points.

I have had a rather imbalanced view about transmutations/isotopic shifts and it was a surprise to see that they were discovered already 1989 when Fleisch and Pons published their work [C15]. Even more, the premature discovery of transmutations for century ago (1910-1930) interpreted by Darwin as a collective effect, was new to me. Articles about transmutations were published in prestigious journals like Nature and Naturwissenschaften. The written history is however history of winners and all traces of this episode disappeared from the history books of physics after the standard model of nuclear physics assuming that nuclear physics and condensed matter physics are totally isolated disciplines. The developments after the establishment of standard model relying on GUT paradigm looks to me surprisingly similar.

Sternglass - still a graduate student - wrote around 1947 to Einstein about his preliminary ideas concerning the possibility to transform protons to neutrons in strong electric fields. It became as a surprise to Sternglass that Einstein supported his ideas. I must say that this increased my respect of Einstein even further. Einstein's physical intuition was marvellous. In 1951 Sternglass found that in strong voltages in keV range protons could be transformed to neutrons with unexpectedly high rate. This is strange since the process is kinematically impossible for free protons: it however can be seen as support for WL model.

Also scientists are humans with their human weaknesses and strengths and the history of CF/LENR is full of examples of both light and dark sides of human nature. Researchers are fighting for funding and the successful production of energy was also the dream of many people involved. There were also people, who saw CF/LENR as a quick manner to become millionaire. Getting a glimpse about this dark side was rewarding. The author knows most of the influential people, who have worked in the field and this gives special authenticity to the books.

It was a great service for the reader the basic view about what happened was stated clearly in the introduction. I noticed also that with some background one can pick up any section and start to read: this is a service for a reader like me. I would have perhaps divided the material into separate parts but probably a less bureaucratic choice leaving room for surprise is better after all.

Who should read these books? The books would be a treasure for any physicist ready to challenge the prevailing prejudices and learn about what science is as seen from the kitchen side. Probably this period will be seen in future as very much analogous to the period leading to the birth of atomic physics and quantum theory. Also layman could enjoy reading the books, especially the stories about the people involved - both scientists and those funding the research and academic power holders - are fascinating. The history of cold fusion is a drama in which one can see as fight between Good and Evil and eventually realize that also Good can divide into Good and Evil. This story teaches about a lot about the role of egos in all branches of sciences and in all human activities. Highly rationally behaving science professionals can suddenly start to behave completely irrationally when their egos feel being under threat.

My hope is that the books could wake up the mainstream colleague to finally realize that CF/LENR or - whatever you wish to call it - is not pseudoscience. Most workers in the field are highly competent, intellectually honest, an have had so deep passion for understanding Nature that they have been ready to suffer all the humiliations that the academic hegemony can offer for dissidents. The results about nuclear transmutations are genuine and pose a strong challenge for the existing physics, and to my opinion force to give up the naive reductionistic paradigm. People building unified theories of physics should be keenly aware of these phenomena challenging the reductionistic paradigm even at the level of nuclear and condensed matter physics.

6.1.3 The problems of WL

For me the first book representing the state of CF/LENR as it was around 2004 was the most interesting. In his first book Krivit sees 1990-2004 period as a gradual transition from the cold fusion paradigm to the realization that nuclear transmutations occur and the fusion model does not explain this process.

In his first book Krivit sees 1990-1999 period as a gradual transition from the cold fusion paradigm to the realization that nuclear transmutations occur and the fusion model does not explain this process.

The basic assumption of the simplest fusion model was that the fusion $D + D \rightarrow^4 He$ explains the production of heat. This excluded the possibility that the phenomenon could take place also in light water with deuterium replaced with hydrogen. It however turned out that also ordinary water allows the process. The basic difficulty is of course Coulomb wall but the model has also difficulties with the reaction signatures and the production rate of ^4He is too low to explain heat production. Furthermore, gamma rays accompanying ^4He production were not observed. The occurrence of transmutations is a further problem. Production of Li was observed already in 1989, and later russia trio Kucherov, Savvatinova, Karabut detected tritium, ^4He, and of heavy elements [C18]. They also observed modifications at the surface of the cathode down to depth of .1-1 micrometers.

Krivit sees LENR as a more realistic approach to the phenomena involved. In LENR Widom-Larsen model (WL) is the starting point [C30, C2, C1, C28, C29]. This would involve no new nuclear physics. I also see WL as a natural starting point but I am skeptic about understanding CF/LENR in term of existing physics. Some new physics seems to be required and I have been doing intense propaganda for a particular kind of new physics [K18].

WL assumes that weak process proton (p)$\rightarrow$ neutron (n) occurring via $e + p \rightarrow n + \nu$ (e denotes electron and ν for neutrino) is the key step in cold fusion. After this step neutron finds its way to nucleus easily and the process continues in conventional sense as analog of r-process assumed to give rise to elements heavier than iron in supernova explosions and leads to the observed nuclear transmutations. Essentially one proton is added in each step decomposing to four sub-steps involving beta decay $n \rightarrow p$ and its reversal.

There are however problems.

1. Already the observations of Sternglass suggest that $e + p \rightarrow n + \nu$ occurs. $e + p \rightarrow n + \nu$ is however kinematically impossible for free particles. e should have considerably higher effective mass perhaps caused by collective many-body effects. $e + p \rightarrow n + \nu$ could occur in the negatively charged surface layer of cathode provided the sum of the rest masses of e and p is larger than that of n. This requires rather large renormalization of electron mass claimed to be due to the presence of strong electric fields. Whether there really exists a mechanism increasing the effective mass of electron, is far from obvious and strong nuclear electric fields are proposed to cause this.

2. Second problematic aspect of WL is the extreme slowness of the rate of beta decay transforming proton to neutron. For ultraslow neutrons the cross section for the absorption of neutron to nucleus increases as $1/v_{rel}$, v_{rel} the relative velocity, and in principle could compensate the extreme slowness of the weak decays. The proposal is that neutrons are ultraslow. This is satisfied if the sum of rest masses is only slightly larger than proton mass. One would have $m_E \simeq m_n - m_p \Delta E_n$, where ΔE_n is the kinetic of neutron. To obtain correct order of magnitude for the rate of neutron absorptions ΔE_n should be indeed extremely small. One should have $\Delta E = 10^{-12}$ eV and one has $\Delta E/m_p = 10^{-21}$! This requires fine tuning and it is difficult to believe that the electric field causing the renormalization could be so precisely fine-tuned.

   ΔE corresponds to extremely low temperature about 10^{-8} K hard to imagine this at room temperature. Thermal energy of the target nucleus at room temperature is of the order $10^{-11} A m_p$, A mass number. Hence it would seem that the thermal motion of the target nuclei mask the effect.

3. One should also understand why gamma rays emitted in the ordinary nuclear interactions after neutron absorption are not detected. The proposal is that gamma rays somehow transform to infrared photons, which would cause the heating. This would be a collective effect involving quantum entanglement of electrons. One might hope that by quantum coherence the neutron absorption rate could be proportional to N^2 instead of N, where N is the number of nuclei involved. This looks logical but I am not convinced about the physical realizability of this proposal.

To my opinion these objections are really serious.

6.2 Comparison with TGD inspired models of CF/LENR or whatever it is

I cannot avoid the temptation to compare WL to my own dilettante models for which also WL has served as an inspiration. I have two models explaining these phenomena in my own TGD Universe. Both models rely on the hierarchy of Planck constants $h_{eff} = n \times h$ [K19, K4] explaining dark matter as ordinary matter in $h_{eff} = n \times h$ phases emerging at quantum criticality. h_{eff} implies scaled up Compton lengths and other quantal lengths making possible quantum coherence is longer scales than usually.

The hierarchy of Planck constants $h_{eff} = n \times h$ has now rather strong theoretical basis and reduces to number theory [L16, L15]. Quantum criticality would be essential for the phenomenon and could explain the critical doping fraction for cathode by D nuclei. Quantum criticality could help to explain the difficulties to replicate the effect.

6.2.1 Simple modification of WL does not work

The first model is a modification of WL and relies on dark variant of weak interactions. In this case LENR would be appropriate term.

1. Concerning the rate of the weak process $e + p \rightarrow n + \nu$ the situation changes if h_{eff} is large enough and rather large values are indeed predicted. h_{eff} could be large also for weak gauge bosons in the situation considered. Below their Compton length weak bosons are effectively massless and this scale would scale up by factor $n = h_{eff}/h$ to almost atomic scale. This would make weak interactions as strong as electromagnetic interactions and long ranged below the Compton length and the transformation of proton to neutron would be a fast process. After that a nuclear reaction sequence initiated by neutron would take place as in WL. There is no need to assume that neutrons are ultraslow but electron mass remains the problem. Note that also proton mass could be higher than normal perhaps due to Coulomb interactions.

2. As such this model does not solve the problem related to the too small electron mass. Nor does it solve the problem posed by gamma ray production.

6.2.2 Dark nucleosynthesis

Also second TGD inspired model involves the h_{eff} hierarchy. Now LENR is not an appropriate term: the most interesting things would occur at the level of dark nuclear physics, which is now a key part of TGD inspired quantum biology.

1. One piece of inspiration comes from the exclusion ones (EZs) of Pollack [L1] [L1], which are negatively charged regions [K18] [L3, L8]. Also the work of the group of Prof. Holmlid [C3, L11] not yet included in the book of Krivit was of great help. TGD proposal [L3, L11] is that protons causing the ionization go to magnetic flux tubes having interpretation in terms of space-time topology in TGD Universe. At flux tubes they have $h_{eff} = n \times h$ and form dark variants of nuclear strings, which are basic structures also for ordinary nuclei.

2. The sequences of dark protons at flux tubes would give rise to dark counterparts of ordinary nuclei proposed to be also nuclear strings but with dark nuclear binding energy, whose scale is measured using as natural unit MeV$/n$, $n = h_{eff}/h$, rather than MeV. The most plausible interpretation is that the field body/magnetic body of the nucleus has $h_{eff} = n \times h$ and is scaled up in size. $n = 2^{11}$ is favoured by the fact that from Holmlid's experiments the distance between dark protons should be about electron Compton length.

   Besides protons also deuterons and even heavier nuclei can end up to the magnetic flux tubes. They would however preserve their size and only the distances between them would be scaled to about electron Compton length on basis of the data provided by Holmlid's experiments [C3, L11].

   The reduced binding energy scale could solve the problems caused by the absence of gamma rays: instead of gamma rays one would have much less energetic photons, say X rays assignable to $n = 2^{11} \simeq m_p/m_e$. For infrared radiation the energy of photons would be about 1 eV and nuclear energy scale would be reduced by a factor about $10^{-6} - 10^{-7}$: one cannot exclude this option either. In fact, several options can be imagined since entire spectrum of h_{eff} is predicted. This prediction is a testable.

Large h_{eff} would also induce quantum coherence is a scale between electron Compton length and atomic size scale.

3. The simplest possibility is that the protons are just added to the growing nuclear string. In each addition one has $(A, Z) \rightarrow (A + 1, Z + 1)$. This is exactly what happens in the mechanism proposed by Widom and Larsen for the simplest reaction sequences already explaining reasonably well the spectrum of end products.

   In WL the addition of a proton is a four-step process. First $e + p \rightarrow n + \nu$ occurs at the surface of the cathode. This requires large electron mass renormalization and fine tuning of the electron mass to be very nearly equal but higher than $n - p$ mass difference.

   There is no need for these questionable assumptions of WL in TGD. Even the assumption that weak bosons correspond to large h_{eff} phase might not be needed but cannot be excluded with further data. The implication would be that the dark proton sequences decay rather rapidly to beta stable nuclei if dark variant of $p \rightarrow n$ is possible.

4. EZs and accompanying flux tubes could be created also in electrolyte: perhaps in the region near cathode, where bubbles are formed. For the flux tubes leading from the system to external world most of the fusion products as well as the liberated nuclear energy would be lost. This could partially explain the poor replicability for the claims about energy production. Some flux tubes could however end at the surface of catalyst under some conditions. Flux tubes could have ends at the catalyst surface. Even in this case the particles emitted in the transformation to ordinary nuclei could be such that they leak out of the system and Holmlid's findings indeed support this possibility.

   If there are negatively charged surfaces present, the flux tubes can end to them since the positively charged dark nuclei at flux tubes and therefore the flux tubes themselves would be attracted by these surfaces. The most obvious candidate is catalyst surface, to which electronic charge waves were assigned by WL. One can wonder whether already Tesla observed in his experiments the leakage of dark matter to various surfaces of the laboratory building. In the collision with the catalyst surface dark nuclei would transform to ordinary nuclei releasing all the ordinary nuclear binding energy. This could create the reported craters at the surface of the target and cause ehating. One cannot of course exclude that nuclear reactions take place between the reaction products and target nuclei. It is quite possible that most dark nuclei leave the system.

   It was in fact Larsen, who realized that there are electronic charge waves propagating along the surface of some catalysts, and for good catalysts such as Gold, they are especially strong. This would suggests that electronic charge waves play a key role in the process. The proposal of WL is that due to the positive electromagnetic interaction energy the dark protons of dark nuclei could have rest mass higher than that of neutron (just as in the ordinary nuclei) and the reaction $e + p \rightarrow n + \nu$ would become possible.

5. Spontaneous beta decays of protons could take place inside dark nuclei just as they occur inside ordinary nuclei. If the weak interactions are as strong as electromagnetic interactions, dark nuclei could rapidly transform to beta stable nuclei containing neutrons: this is also a testable prediction. Also dark strong interactions would proceed rather fast and the dark nuclei at magnetic flux tubes could be stable in the final state. If dark stability means same as the ordinary stability then also the isotope shifted nuclei would be stable. There is evidence that this is the case.

Neither "CF" nor "LENR" is appropriate term for TGD inspired option. One would not have ordinary nuclear reactions: nuclei would be created as dark proton sequences and the nuclear physics involved is in considerably smaller energy scale than usually. This mechanism could allow at least the generation of nuclei heavier than Fe not possible inside stars and supernova explosions would not be needed to achieve this. The observation that transmuted nuclei are observed in four bands for nuclear charge Z irrespective of the catalyst used suggest that catalyst itself does not determined the outcome.

One can of course wonder whether even "transmutation" is an appropriate term now. Dark nucleosynthesis, which could in fact be the mechanism of also ordinary nucleosynthesis outside stellar interiors explain how elements heavier than iron are produced, might be more appropriate term.

6.3 More about dark nucleosynthesis

In the sequel a more detailed view about dark nucleosynthesis is developed using the information provided by the first book of Krivit. This information allows to make also the nuclear string model much more detailed and connect CF/LENR with co called X boson anomaly and other nuclear anomalies.

6.3.1 Not only sequences of dark protons but also of dark nucleons are involved

Are only dark protons sequences at magnetic flux tubes involved or can these sequences consists of nuclei so that one would have nucleus consisting of nuclei? From the first book I learned, that the experiments of Urutskoev [**?**] demonstrate that there are 4 peaks for the production rate of elements as function of atomic number Z. Furthermore, the amount of mass assignable to the transmuted elements is nearly the mass lost from the cathode. Hence also cathode nuclei should end up to flux tubes.

1. Entire target nuclei can become dark in the sense described and end up to the same magnetic flux tubes as the protons coming from bubbles of electrolyte, and participate in dark nuclear reactions with the incoming dark nuclei: the dark nuclear energy scale would be much smaller than MeV. For heavy water electrolyte D must become dark nucleus: the distance between p and n inside D would be usual. A natural expectation is that the flux tubes connect the EZs and cathode.

   In the transformation to ordinary nuclear matter these nuclei of nuclei would fuse to ordinary nuclei and liberate nuclear energy associated with the formation of ordinary nuclear bonds.

2. The transformation of protons to neutrons in strong electric fields observed already by Sternglass in 1951 could be understood as a formation of flux tubes containing dark nuclei and producing neutrons in their decays to ordinary nuclei. The needed voltages are in kV range suggesting that the scale of dark nuclear binding energy is of order keV implying $h_{eff}/h = n \sim 2^{11}$ - roughly the ratio m_p/m_e.

3. Remarkably, also in ordinary nuclei the flux tubes connecting nucleons to nuclear string would be long, much longer than the nucleon Compton length [K10] btartXboson. By ordinary Uncertainty Principle ($h_{eff} = h$) the length of flux tube to which binding energy is assigned would correspond to the size of nuclear binding energy scale of order few MeV. This would be also the distance between dark $h_{eff} = n \times h$ nuclei forming dark nuclear string! The binding energy would be scaled down by $1/n$.

   This suggests that $n \rightarrow 1$ phase transition does not affect the lengths of flux tubes but only turns them to loops and that the distance between nucleons as measured in $M^4 \times CP_2$ is therefore scaled down by $1/n$. Coulomb repulsion between proton does not prevent this if the electric flux between protons is channelled along the long flux tubes rather than along larger space-time sheet so that the repulsive Coulomb interaction energy is not affected in the phase transition! This line of thought obviously involves the notion of space-time as a 4-surface in crucial manner.

4. Dark nuclei could have also ordinary nuclei as building bricks in accordance with fractality of TGD. Nuclei at dark flux tubes would be ordinary and the flux tubes portions - bonds - between them would have large h_{eff} and ahve thus length considerably longer than in ordinary nuclei. This would give sequences of ordinary nuclei with dark binding energy: similar situation is actually assumed to hold true for the nucleons of ordinary nuclei connected by analogs of dark mesons with masses in MeV range [K10].

Remark: In TGD inspired model for quantum biology dark variants of biologically important ions are assumed to be present. Dark proton sequences having basic entangled unit consisting of 3 protons analogous to DNA triplet would represent analogs of DNA, RNA, amino-acids and tRNA [L7]. Genetic code would be realized already at the level of dark nuclear physics and biochemical realization would represent kind of shadow dynamics. The number of dark codons coding for given dark amino-acid would be same as in vertebrate genetic code.

6.3.2 How dark nuclei are transformed to ordinary nuclei?

What happens in the transformation of dark nuclei to ordinary ones? Nuclear binding energy is liberated but how does this occur? If gamma rays generated, one should invent also now a mechanism transforming gamma rays to thermal radiation. The findings of Holmlid provide valuable information here and lead to a detailed qualitative view about process and also allow to sharpen the model for ordinary nuclei.

1. Holmlid [L11] [L11] [K18] has reported rather strange finding that muons (mass 106 MeV) pions (mass 140 MeV) and even kaons (mass 497) MeV are emitted in the process. This does not fit at all to ordinary nuclear physics with natural binding energy scale of few MeVs. It could be that a considerable part of energy is liberated as mesons decaying to lepton pairs (pions also to gamma pairs) but with energies much above the upper bound of about 7 MeV for the range of energies missing from the detected gamma ray spectrum (this is discussed in the first part of the book of Krivit [C26]).

   As if even hadronic interactions would enter the game somehow! Already condensed matter physics and nuclear physics in the same coffee table are too much fort the mainstream physicist!

2. What happens when the liberated total binding energy is below pion mass? There is experimental evidence for what is called X boson [C8] discussed from TGD point of view in [L12]. In TGD framework X is identified as a scaled down variant $\pi(113)$ of ordinary pion $\pi = \pi(107)$. X is predicted to have mass of $m(\pi(113)) = 2^{(113-107)/2}m(\pi) \simeq 16.68$ MeV, which conforms with the mass estimate for X boson. Note that $k = 113$ *resp.* $k = 117$ corresponds to nuclear *resp.* hadronic p-adic length scale. For low mass transmutations the binding energy could be liberated by emission of X bosons and gamma rays.

3. I have also proposed that pion and also other neutral pseudo-scalar states could have p-adically scaled variants with masses differing by powers of two. For pion the scaled variants would have masses 8.5 MeV, $m(\pi(113)) = 17$ MeV, 34 MeV, 68 MeV, $m(\pi(107)) = 136$ MeV, ... and also these could be emitted and decay to lepton pairs of gamma pairs [K9]. The emission of scaled pions could be faster process than emission of gamma rays and allow to emit the binding energy with minimum number of gamma rays.

There is indeed evidence for pion like states (for TGD inspired comments see [K9]).

1. The experimental claim (see `http://tinyurl.com/ybq323yy`) of Tatischeff and Tomasi-Gustafsson is that pion is accompanied by pion like states organized on Regge trajectory and having mass 60, 80, 100, 140, 181, 198, 215, 227.5, and 235 MeV. For TGD inspired comments see [K9].

2. A further piece of evidence for scaled variants of pion comes from two articles by Eef van Beveren and George Rupp. The first article [C4] is titled *First indications of the existence of a 38 MeV light scalar boson* (see `http://tinyurl.com/yatlb97o`). Second article [C5] has title *Material evidence of a 38 MeV boson* (see `http://tinyurl.com/yczo7juy`).

The above picture suggests that the pieces of dark nuclear string connecting the nucleons are looped and nucleons collapse to a nucleus sized region. On the other, the emission of mesons suggests that these pieces contract to much shorter pieces with length of order Compton length of meson responsible for binding and the binding energy is emitted as single quantum or very few quanta. Strings cannot however retain their length (albeit becoming looped with ends very near in $M^4 \times CP_2$) and contract at the same time! How could one unify these two conflicting pictures?

1. To see how TGD could solve the puzzle, consider what elementary particles look like in TGD Universe [K9]. Elementary particles are identified as two-sheeted structures consisting of two space-time sheets with Minkowskian signature of the induced metric connected by CP_2 sized wormhole contacts with Euclidian signature of induced metric. One has a pair of wormhole contacts and both of them have two throats analogous to blackhole horizons serving as carriers of elementary particle quantum numbers.

   Wormhole throats correspond to homologically trivial 2-surfaces of CP_2 being therefore Kähler magnetically charged monopole like entities. Wormhole throat at given space-time sheet is necessarily connected by a monopole flux tube to another throat, now the throat of second wormhole contact. Flux tubes must be closed and therefore consist of 2 "long" pieces connecting wormhole throats at different parallel space-time sheets plus 2 wormhole contacts of CP_2 size scale connecting these pieces at their ends. The structure resembles extremely flattened rectangle.

2. The alert reader can guess the solution of the puzzle now. The looped string corresponds to string portion at the non-contracted space-time sheet and contracted string to that at contracted space-time sheet! The first sheet could have ordinary value of Planck constant but larger p-adic length scale of order electron's p-adic length scale $L(127)$ (it could correspond to the magnetic body of ordinary nucleon [L12]) and second sheet could correspond to $h_{eff} = n \times h$ dark variant of nuclear space-time sheet with $n = 2^{11}$ so that the size scales are same.

   The phase transition $h_{eff} \rightarrow h$ occurs only for the flux tubes of the second space-time sheet reducing the size of this space-time sheet to that of nuclear $k = 137$ space-time sheet of size of $\sim 10^{-14}$ meters. The portions of the flux tubes at this space-time sheet become short, at most of the order of nuclear size scale, which roughly corresponds to pion Compton length. The contraction is accompanied by the emission of the ordinary nuclear binding energy as pions, their scaled variants, and even heavier mesons. This if the mass of the dark nucleus is large enough to guarantee that total binding energy makes the emission possible. The second space-time sheet retains its size but the flux tubes at it retain their length but become loopy since their ends must follow the ends of the shortened flux tubes.

3. If this picture is correct, most of the energy produced in the process could be lost as mesons, possibly also their scaled variants. One should have some manner to prevent the leakage of this energy from the system in order to make the process effective energy producer.

4. The is however an important question to be answered. The basic hypothesis has been that the dark $h_{eff}(h = n$ variants of elementary particles have same masses as the ordinary elementary particles particles. Hadrons are however many-quark systems and this need not be true anymore. Could proton and neutron masses change?

   The model for Pollack effect does not allow significant change of proton mass. If also neutron mass remains un-affected and nuclear binding energies are scaled down by factor 2^{-11}, one ends up with difficulties. n-p mass difference is about 1.3 MeV and its scale would be much higher than the few keV scale for scaled down nuclear binding energies. Stable dark nuclei would consist of protons only and the transformation to ordinary nuclei would require emission of charge particles, say scaled variants of pion (which could be emitted in any way with a higher rate than gamma rays).

   If n-p mass difference is scaled down by factor 2^{-11} to .65 keV, one has scaling invariance and the spectrum of dark nuclei would be essentially similar to that of ordinary nuclei and dark beta decays would lead rapidly to beta stable dark nuclei. In particular, dark variants of beta decays involving the emission of e^+ become possible and can transform dark protons to dark neutrons. Notice, the assumption of WL about large renormalization of proton mass implying $m_{R,p} + m_e \simeq m_n$ in an excellent approximation is analogous to this hypothesis.

6.3.3 Dark nucleosynthesis and stellar evolution

The temperature of the solar core is rather near to the scale of dark nuclear binding energy. This co-incidence inspires interesting questions about the dark nucleosynthesis in the stellar evolution.

1. Some questions inspired by a numerical co-incidence

The temperature at solar core is about $T = 1.5 \times 10^7$ K corresponding to the thermal energy $E = 3T/2 = 2.25$ keV obtained by a scaling factor 2^{-11} energy ~ 5 MeV, which is the binding energy scale for the ordinary nuclei. That this temperature corresponds to the binding energy scale of dark nuclei might not be an accident.

That the temperature in the stellar core is of the same order of magnitude as dark nuclear binding energy is a highly intriguing finding and encourages to ask whether dark nuclear fusion could be the key step in the production of ordinary nuclei and what is the relation of dark nucleosynthesis to ordinary nucleosynthesis.

1. Could dark nucleosynthesis occur also pre-stellar evolution and thus proceed differently from the usual p-p-cycle involving fusion processes? The resulting ordinary nuclei would undergo only ordinary nuclear reactions and decouple from the dark dynamics. This does not exclude the possibility that the resulting ordinary nuclei form nuclei of nuclei with dark protons: this seems to occur also in nuclear transmutations.

2. There would be two competing effects. The higher the temperature, the less stable dark nuclei and the longer the dark nuclear strings. At lower temperatures dark nuclei are more stable but transform to ordinary nuclei decoupling from the dark dynamics. The liberated nuclear binding energy however raises the temperature and makes dark nuclei less stable so that the production of ordinary nuclei in this manner would slow down.

   At what stage ordinary nuclear reactions begin to dominate over dark nucleosynthesis? The conservative and plausible looking view is that p-p cycle is indeed at work in stellar cores and has replaced dark nucleosynthesis when dark nuclei became thermally unstable.

   The standard view is that solar temperature makes possible tunnelling through Coulomb wall and thus ordinary nuclear reactions. The temperature is few keVs and surprisingly small as compared to the height of Coulomb wall $E_c \sim Z_1 Z_2 e^2/L$, L the size of the nucleus. There are good reasons to believe that this picture is correct. The co-incidence of the two temperatures would make possible the transition from dark nucleosynthesis to ordinary nucleosynthesis.

3. What about dark nuclear reactions? Could they occur as reconnections of long magnetic flux tubes? For ordinary nuclei reconnections of short flux tubes would take place (recall the view about nuclei as two-sheeted structures). For ordinary nuclear the reactions at energies so low that the phase transition to dark phase (somewhat analogous to the de-confinement phase transition in QCD) is not energetically possible, the reactions would occur in nuclear scale.

4. An interesting question is whether dark nucleosynthesis could provide a new manner to achieve ordinary nuclear fusion in laboratory. The system would heat itself to the temperatures required by ordinary nuclear fusion as it would do also during the pre-stellar evolution and when nuclear reactor is formed spontaneously (Oklo reactor, see `http://tinyurl.com/l3h6t9v`).

2. Could dark nucleosynthesis affect the views about stellar evolution?

The presence of dark nucleosynthesis could modify the views about star formation (see `http://tinyurl.com/ybdv79gg`), in particular about energy production in protostars (see `http://tinyurl.com/l4htsob`) and pre-main-sequence stars (PMS, see `http://tinyurl.com/y8bfbvk7`) following protostars in stellar evolution.

In protostars and PMSs the temperature is not yet high enough for the burning of hydrogen to ^{4}He, and according to the standard model the energy radiated by the star consists of the gravitational energy liberated during the gravitational contraction. Could dark nucleosynthesis provide a new mechanism of energy production and could this energy be transferred from the protostar/PMS as dark energy along dark magnetic flux tubes?

Can one imagine any empirical evidence for the presence of dark nucleosynthesis in protostars and PMSs?

1. The energy and matter produced in dark nucleosynthesis could partially leak out along dark magnetic flux tubes and give rise to astrophysical jets (see `http://tinyurl.com/yb7g9ryx`). Astrophysical jets indeed accompany protostars and the associated planetary and bipolar nebulae as well as PMSs (T Tauri stars and Herbig-Haro objects). The jets along flux tubes associated with hot spots at which dark nucleosynthesis would take place could provide also a mechanism for the transfer of angular momentum from the protostar/PMS.

2. Spectroscopic observations of dense cores (protostar) not yet containing stars indicate that contraction occurs but the predicted expansion of the contracting region has not been observed (see `http://tinyurl.com/l4htsob`). The energy production by dark nucleosynthesis could increase pressure and slow down and even prevent the expansion of the contracting region.

How dark nucleosynthesis could affect the evolution of protostars and PMSs?

1. In standard model the formation of accretion disk (see `http://tinyurl.com/yaax8ruq`) could be understood in terms of angular momentum conservation: spherical distribution of matter transforms to a planar one does not require large changes for the velocities tangential to the plane. The mechanism for how the matter from accretion disk spirals into star is however poorly understood.

2. The TGD inspired model for galaxy formation suggests that the core region of the protostar is associated with a highly knotted cosmic string ("pearl in a necklace") forming the dark core of galaxy with constant density of dark matter [L13]. The dark matter from the cosmic string would have leaked out from the cosmic string and transformed to ordinary matter already before the annihilation of quarks and antiquarks. The CP, P, and T asymmetries predicted by twistor lift of TGD would predict that there is a net quark (antiquark) number outside (inside) the cosmic string. The locally axisymmetric gravitational potential of the cosmic string would favour disk like rather than spherically symmetric matter distribution as the initial distribution of the baryonic matter formed in the hadronization from the quarks left from the annihilation.

   Quantitative model is needed to see whether dark fusion could contribute significantly to the energy production in protostars and PMSs and affect their evolution. The nuclear binding energy liberated in dark fusion would slow down the gravitational contraction and increase the duration of protostar and PMS phases. In standard model PMS phase is possible for masses varying from 2 to 8 solar masses. Dark nucleosynthesis could increase the upper bound for the mass of PMS from that predicted by the standard model.

This is only rough overall view and it would be unrealistic to regard it as final one: one can indeed imagine variations. But even its recent rough form it seems to be able explain all the weird looking aspects of CF/LENR/dark nucleosynthesis. To pick up one particular interesting question: how significantly dark nucleosynthesis could contribute to the generation of elements heavier than Fe (and also lighter elements)? It is assumed that the heavier elements are generated in so called r-process involving creation of neutrons fusing with nuclei. One option is that r-process accompanies supernova explosions but SN1987A did not provide support for this hypothesis: the characteristic em radiation accompanying r-process was not detected. Quite recently the observation of gravitational waves from the fusion of two neutron stars generated also visible radiation, so called kilonova (see `http://tinyurl.com/ycagjeau`), and the radiation accompanying r-process was reported. Therefore this kind of collisions generate at least part of the heavier elements.

6.4 "Fusion fiasco" and "Lost history" from TGD perspective

In the following the second and third volume of "*Explorations in Nuclear Research*" of Krivit are discussed from TGD point of view. The intention is to use the information provided by these books in order to refine the model for dark nucleosynthesis.

6.4.1 Summary of the model of dark nucleosynthesis model

Before continuing it is good to recall first the basic ideas behind dark nucleosynthesis.

1. Dark nuclei are produced as dark proton sequences at magnetic flux tubes with distance between dark protons with $h_{eff}/h = 2^{11}$ (approximately proton/electron mass ratio) very near to electron Compton length. This makes possible formation of at least light elements when dark nuclei transform to ordinary ones and liberate almost entire nuclear binding energy.

2. Also more complex nuclei can form as nuclei of nuclei from ordinary nuclei and sequences of dark protons are at magnetic flux tubes. In particular, the basic rule $(A, Z) \rightarrow (A+1, Z+1)$ of Widom-Larsen model is satisfied although dark beta decays would break this rule.

   In this case the transformation to ordinary nuclei produces heavier nuclei, even those heavier than Fe. This mechanism could make possible the production of heavy nuclei outside stellar interiors. Also dark beta decays can be considered. They would be fast: the idea is that the Compton length of weak bosons is scaled up and within the region of size scale of Compton length weak interactions have essentially the same strength as electromagnetic interactions so that weak decays are fast and led to dark isotopes stable against weak interactions.

3. The transformation of dark nuclei to ordinary nuclei liberates almost all nuclear binding energy. This energy could induce the fission of the daughter nucleus and emission of neurons causing the decay of ordinary nuclei, at least those heavier than Fe.

4. Also the dark weak process $e^- + p \rightarrow n + \nu$ liberating energy of order electron mass could kick out neutron from dark nucleus. This process would be TGD counterpart for the corresponding process in WL but having very different physical interpretation. This mechanism could explain production of neutrons which is by about 8 orders slower than in cold fusion model.

5. The magnetic flux tubes containing dark nuclei form a positively charged system attracted by negatively charged surfaces. The cathode is where the electrons usually flow to. The electrons can generate negative surface charge, which attracts the flux tubes so that flux tubes end up to the cathode surface and dark ions can enter to the surface. Also ordinary nuclei from the cathode could enter temporarily to the flux tube so that more complex dark nuclei consisting of dark protons and nuclei are formed. Dark nuclei can also leak out of the system if the flux tube ends to some negatively charged surface other than cathode.

The findings described in the two books, in particular the production of neutrons and tritium, allow to sharpen the view about dark nucleosynthesis.

1. The simplest view about dark nucleosynthesis is as a formation of dark proton sequences in which some dark protons transform by beta decay (emission of positron) to neutrons. The objection is that this decay is kinematically forbidden if the masses of dark proton and neutron are same as those of ordinary proton and neutron (n-p mass difference is 1.3 MeV). Only dark proton sequences would be stable.

   Situation changes if also n-p mass difference scales by factor 2^{-11}. The spectra of dark and ordinary nuclei would be essentially identical. For scaled down n-p mass difference, neutrons would be produced most naturally in the process $e^- + p \rightarrow n + \nu$ for dark nuclei proceeding via dark weak interactions. The dark neutron would receive a large recoil energy about $m_e \simeq .5$ MeV and dark nucleus would decay. The electrons inducing the neutron emission could come from the negatively charged surface of cathode after the flux tube has attached to it. The rate for $e^- + p \rightarrow n + \nu$ is very law for ordinary weak Planck constant. The ratio $n/T \sim 10^{-8}$ allows to deduce information about h_{eff}/h: a good guess is that dark weak process is in question.

2. Tritium and other isotopes would be produced as several magnetic flux tubes connect to a negatively charged hot spot of cathode. A reasonable assumption is that the ordinary binding energy gives rise to an excited state of the ordinary nucleus. This can induce the fission of the final state nucleus and also neutrons can be produced. Also scaled down variants of pions can be emitted, in particular the pion with mass of 17 MeV [L12].

Table 1: The ordinary nuclear binding energies E_B for light nuclei and the energies ΔE liberated in dark $\rightarrow$ ordinary transition.

$Element$	^4He	^3He	T	D
E_B/MeV	28.28	7.72	8.48	2.57
$\Delta E/MeV$	25.70	6.412	5.8	1.27

3. The ordinary nuclear binding energy minus the n-p mass difference 1.3 MeV multiplied by the number of neutrons would be released in the transformation of dark nuclei to ordinary ones. The table 1 gives the total binding energies and liberated energies for some lightest stable nuclei.

   Gamma rays are not wanted in the final state. For instance, for the transformation of dark ^{4}He to ordinary one, the liberated energy would be about 25.7 MeV. If the final state nucleus is in excited state unstable against fission, the binding energy can go to the kinetic energy of the final state and not gamma ray pairs are observed. If two 17 MeV pions π_{113} are emitted the other one or both must be on mass shell and decay weakly. The decay of off-mass π_{113} could however proceed via dark weak interactions and be fast so that the rate for this process could be considerably faster than for the emission of two gamma rays.

6.4.2 Fusion fiasco from TGD perspective

The second volume of the book "*Explorations in Nuclear Research*" of Krivit is titled (see `http://stevenbkrivit.com/fusion-fiasco/`). The book gives a very detailed view about what happened during the first years after the discovery of Pons of Fleischman of energy production in electrolysis (in 1989) not understandable in terms of chemistry. Their interpretation was as cold fusion was definitely wrong and gave an excellent weapon for those wanting to label them as crackpots.

From TGD point of view especially interesting observations related to the observations of Indian and Italian research group made immediately after the announcement of the results of Pons and Fleischman. The observations of Indian groups working in Babbha Atomic Research Center (BARC) were led by Mahadeva Shrinivasan and Padmanabha Krisnagopala Iyengar. Yengar was the director BARC and Shrinivasa the director of the physics group working in BARC. The three leading researchers in Italian ENEA-Frascati experiment were Fransesco Scaramuzzi, Antonella De Ninno and Antonio Frattolillo.

The results of both experiments were rather similar and I will summarize in the following only the findings of Indians. Tritium and neutron production were detected by 6 independent groups. The basic prediction of D+D fusion model is that equal amounts of neutrons and tritium nuclei should be produced in D+D$\rightarrow$ n+T process occurring besides D+D $\rightarrow$ ^{4}He. These groups tested this hypothesis and found that the n/T ratio is small: in the range $(10^{-9}, 10^{-8})$ in BARC experiments so that D+D fusion hypothesis cannot be correct. What is however remarkable is that neutrons were produced and one should understand this also in TGD framework.

Milton-Roy electrolytic cell consisting of 16 Pd-Ag alloy membrane tubes with total area of 300 cm^2 was used. For instance, 30 amp current rising gradually to 60 amp was used in one of the runs using Pd as host metal. Also experiments replacing Pd with Ti as a host metal were performed. Three types of neutron detectors were used to detect cold, thermal, and high energy neutrons: BF_3 detector was used for cold neutrons, ^3He detector for thermal neutrons, and scintillation counter for high energy neutrons. Comparison with the neutron background was performed. All counters detected the neutrons simultaneously.

What was found was following.

1. During 4-hour run 4×10^7 neutrons were observed: this is considerably above background. n/T ratio was in the range $10^{-6} - 10^{-9}$ and its average was 10^{-7}. This does not conform with the D+D fusion model.

2. Two groups at BARC observed n and T bursts with 10-20 neutrons in single burst. Neutron and tritium bursts were strongly correlated suggesting that some kind of chain reaction was

involved. Bursts occurred only in the first day, after few hours of charging. After that the emission of neutrons stopped.

3. The interpretation was as surface phenomenon occurring only at hot spots whereas Pons and Fleischman assumed that the process occurs in the entire cathode.

What could be the TGD interpretation?

The simplest version of dark nucleosynthesis assumes only the formation of dark proton sequences.

1. The resulting dark nuclear strings suffered dark beta decays leading to the counterparts of ordinary nuclei. These transformed to ordinary nuclei and the ordinary nuclear binding energy was liberated. The transformation to ordinary nucleus in excited state suffering fission or emitting gamma ray pair (at least) are the most plausible decay channels. Fission channel is the faster one. This could explain the production of neutrons and the low n/T branching ratio.

2. One can also consider a formation of dark nuclei containing besides dark protons also ordinary nuclei: nuclear string consisting of nuclei would be in question.

3. Dark nuclear fusion does not look so plausible option.

   (a) Could a dark version p-p cycle assumed to produce ^4He in stars like Sun be involved? This process involves several steps. p+p gives rise D and positron+ neutrino. D and p fuse to ^{3}He liberating energy. Final step would be ^{3}He+ ^{3}He $\rightarrow$ ^{4}He + p+p. Could these steps could take for dark nuclei so that scale of liberated energy would be by factor 2^{-11} smaller than for ordinary nuclear process.

   (b) Also D+D, D+T, and D+^{3}He fusions could occur

   - D+D $\rightarrow$ ^{4}He
   - D+D $\rightarrow$ ^{3}He + n
   - D+D $\rightarrow$ T + p
   - D+ T $\rightarrow$ ^{4}He + n
   - D+^{3}He $\rightarrow$ ^{4}He + p

   D+D produces ^3He +n or T + p. D+T to produces $^4He + n$. It would seem that the number of neutrons should be larger than the number of T. This prediction does not conform with the small n/T branching fraction. These reactions could of course take place but their contribution should be rather small as compared to that assignable to the transformation of dark nuclei to ordinary ones.

Can one understand the other observations in TGD framework?

1. The production of tritium and neutrons seems to occur in hot spots at the surface of the cathode and only during the initial stages of the experiment. Hot spots could correspond to negatively charge pieces of the cathode surfaces. The negatively charged cathode surface attracts the magnetic flux tubes. As positive charge flows to the surface, the density of electrons at the surface is weakened and the process ceases to occur.

2. Neutrons were produced as bursts, say 10-20 neutrons. The decays of dark nuclei could explain these bursts but several flux tubes are required sin single flux tube is expected to produce only few neutrons. The total number of flux tubes is expected to be proportional to the area of hot spots.

6.4.3 The lost history from TGD perspective

The third volume in "*Explorations in Nuclear Research*" [C27] is about lost history: roughly the period 1910-1930 during which there was not yet any sharp distinction between chemistry and nuclear physics. After 1930 the experimentation became active using radioactive sources and particle accelerators making possible nuclear reactions. The lost history suggests that the methods used determine to unexpected degree what findings are accepted as real. After 1940 the hot fusion as possible manner to liberate nuclear energy became a topic of study but we are still waiting the commercial applications.

One can say that the findings about nuclear transmutations during period 1912-1927 became lost history although most of these findings were published in highly respected journals and received also media attention. Interested reader can find in the book detailed stories about persons involved. This allows also to peek to the kitchen side of science and to realize that the written history can contain surprising misidentifications of the milestones in the history of science. Author discusses in detail an example about this: Rutherford is generally regarded as tje discover of the first nuclear transmutation but even Rutherford himself did not make this claim.

It is interesting to look what the vision about the anomalous nuclear effects based on dark nucleosynthesis can say about the lost history and whether these findings can provide new information to tighten up the TGD based model, which is only qualitative. Therefore I go through the list given in the beginning of book from the perspective of dark nucleosynthesis.

1. Production of noble gases and tritium

During period 1912-1914 several independent scientists discovered the production of noble gases ^{4}He, neon (Ne), and argon (Ar) using high voltage electrical discharges in vacuum or r through hydrogen gas at low pressures in cathode-ray tubes. Also an unidentified element with mass number 3 was discovered. It was later identified as tritium. Two of the researchers were Nobel laureates. 1922 two researchers in University of Chicago reported production of ^{4}He. Sir Joseph John Thomson explained the production of ^{4}He using occlusion hypothesis. In understand occlusion as a contamination of ^{4}He to the tungsten wire. The question is why not also hydrogen.

Why noble gases would have been produced? It is known that noble gases tend to stay near surfaces. In one experiment it was found that ^4He production stopped after few days, maybe kind of saturation was achieved. This suggests that isotopes with relatively high mass numbers were produced from dark proton sequences (possibly containing also neutrons resulting in the dark weak decays). The resulting noble gases were caught near the electrodes and therefore only their production was observed.

2. Production of ^4He in experiments of Wendle and Irion

In 1222 Wendle and Irion published results from the study of exploding current wires. Their arrangement involved high voltage of about 3×10^4 V and di-electric breakdown through air gap between the electrodes producing sudden current peak in a current wire made of tungsten (W with $(Z, A) = (74, 186)$ for the most abundant isotope) at temperature about $T = 2 \times 10^4$ C, which corresponds to a thermal energy $3kT/2$ of about 3 eV. Production of ^{4}He was detected.

Remark: The temperature at solar core is about 1.5×10^7 K corresponding to energy about 2.25 keV and 3 orders of magnitude higher than the temperature used.

The interpretation of the experimentalists was that the observed ^{4}He was from the decay of tungsten in the hot temperature making it unstable. This explanation is of course not consistent with what we known at about nuclear physics. No error in the experimental procedure was found. Three trials to replicate the experiment of Wendle and Irion were made with a negative result. The book discusses these attempts in detail and demonstrates that they were not faithful to the original experimental arrangement.

Rutherford explained the production of ^{4}He in terms of ^{4}He occlusion hypothesis of Thomson. In the explosion the ^{4}He contaminate would have liberated. But why just helium contamination, why not hydrogen? By above argument one could argue that ^4He as noble gas could indeed form stable contaminates.

80 yeas later Urutskoev repeated the experiment with exploding wires and observed besides ^{4}He also other isotopes. The experiments of Urutskoev [**?**] demonstrated that there are 4 peaks for the production rate of elements as function of atomic number Z. Furthermore, the amount of mass assignable to the transmuted elements is nearly the mass lost from the cathode. Hence also cathode nuclei should end up to flux tubes.

How dark nucleosynthesis could explain the findings? The simplest model relies on a modification of the occlusion hypothesis: a hydrogen contaminate was present and the formation of dark nuclei from the protons of hydrogen at flux tubes took place in the exploding wire. The nuclei of noble gases tended to remain in the system and ^{4}He was observed.

Table 2: The nuclear charge and mass number (Z, A) for the most abundant isotopes of W, Pt, Au,Hg, Tl and Pb.

Element	*W*	*Pt*	*Au*	*Hg*	*Tl*	Pb
(Z, A)	(74,186)	(78,195)	(79,197)	(80,202)	(81,205)	(82,208)

3. Production of Au and Pt in arc discharges in Mercury vapor

In 1924 German chemist Miethe, better known as the discoverer of 3-color photography found trace amount of Gold (Au) and possibly Platinum (Pt) in Mercury (Hg) vapor photography lamp. Scientists in Amsterdam repeated the experiment but using lead (Pb) instead of Hg and observed production of Hg and Thallium (Tl). The same year a prominent Japanese scientist Nagaoka reported production of Au and something having the appearance of Pt. Nagaoka used a an electric arc discharge between tungsten (W) electrodes bathed in dielectric liquid "laced" with liquid Hg.

The nuclear charges and atomic weights for isotopes involved are given in table 2 .

Could dark nucleosynthesis explain the observations? Two mechanisms for producing heavier nuclei relying one the formation of dark nuclei from the nuclei of the electrode metal and dark protons and their subsequent transformation to ordinary nuclei.

1. Dark nuclei are formed from the metal associated with cathode and dark protons. In Nagaoka's experiment this metal is W with $(Z, A) = (74, 186)$. Assuming that also dark beta decays are possible this would lead to the generation of heavier beta stable elements Au with $(Z, A) = (79, 197)$ or their stable isotopes. Unfortunately, I could not find what the electrode metal used in the experiments of Miethe was.

2. In the experiments of Miethe the nuclei of Hg transmuted to Au $((80, 202) \rightarrow (79, 197))$ and to Pt $((80, 202) \rightarrow (78, 195))$. In Amsterdam experiment of Pb transmuted to Hg $((82, 208) \rightarrow (80, 202))$ and Tl $((82, 208) \rightarrow (81, 205))$. This suggests that the nuclei resulted in the decay of Hg (Pb) induced by the nuclear binding energy liberated in the transformation of dark nuclei formed from the nuclei of cathode metal and dark protons to ordinary nuclei. Part of the liberated binding energy could have induced the fission of the dark nuclei. The decay of dark nuclei could have also liberated neutrons absorbed by the Hg (Pb) nuclei and inducing the decay to lighter nuclei. Thus also the analog of r-process could have been present.

4. Paneth and Peters' H→ ^4He transmutation

In 1926 German chemists Paneth and Peters pumped hydrogen gas into a chamber with finely divided palladium powder and reported the transmutation of hydrogen to helium. This experiment resembles the "cold fusion" experiment of Pons and Fleischman in 1989. The explanation would be the formation of dark ^4He nuclei consisting of dark protons and transformation to ordinary ^4He nuclei.

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