Could TGD provide new solutions to the energy problem?

M. Pitkänen
Email: matpitka6@gmail.com.
http://tgdtheory.com/.

March 31, 2020

Abstract

Topological Geometrodynamics (TGD) leads to new physics both classically and at quantum level. This new physics could provide a solution to the energy problem. Artificial photosynthesis, nuclear fission, hot fusion and also "cold fusion" have received a considerable attention as solutions of this problem. TGD has led to a model of "cold fusion" (CF), which was later generalized to a model for nuclear physics applicable also to hot fusion and to explain a 10 year old anomaly in the nuclear physics of Sun.

TGD leads also to a model of quantum biology relying on new quantum physics. This model could provide a theoretical basis for the understanding of photosynthesis. This article provides first an introduction to CF, and then a brief summary about TGD as a unification of fundamental interactions and its applications to quantum biology and to theory of consciousness as generalization of quantum measurement theory. Finally TGD based model of CF and how it could help in the development of energy technology is discussed.

What is remarkable that both CF and ordinary nuclear reactions would proceed by essentially the same mechanism as bio-catalysis made possible by quantum criticality and phase transitions changing length scale dependent cosmological constant predicted by TGD. By fractality of TGD Universe this mechanism could actually apply in all scales from astrophysics to hadron physics and even in phase transition that was expected to correspond to color de-confinement.

Contents

1 Introduction

The city of Helsinki has posed an ambitious goal to be carbon neutral before year 2035. The role of Helsinki could be therefore decisive in the fight agains climate crisis. More than half of the population of the world lives in towns and more than 2/3 of the energy is consumed by cities and are responsible for more than 70 per cent of the carbon oxide emission of the world. About 56 per cent of the carbon oxide emissions of Helsinki are due to the heating. Finding of a sustainable heating method has a decisive effect on the total amount of carbon oxide emissions of Helsinki.

Concerning heat production Helsinki is searching for new kind of thinking and internal collaboration. The goal is to search for the solutions to energy problems even in the world scale. Therefore Helsinki city as challenged innovators and the specialist of the field to sustained solutions to the production of energy in a competition. The competition "Helsinki Energy Challenge" opened February 27 2020 is international.

1.1 Could artificial photosynthesis or nuclear energy be a solution to the energy problem?

The requirement of carbon neutrality leaves allows renewable energy sources, energy efficiency, and concentration of pure low carbon technologies (`http://tinyurl.com/te8uhl7`). The understanding of photosynthesis could make possible to mimic it technologically and is is a promising approach. Nuclear energy is another alternative despite its problems.

1.1.1 The options related to nuclear energy

There are three options related to nuclear power.

1. At this moment the power plants use fission of heavy nuclei, which liberates energy because the nuclear binding energy per nucleon decreases as the mass number of the nucleus increases.

   The problem is that one obtains as a waste long-lived isotopes which are unstable against decay and produce radiation, which is dangerous for health. The storage of the waste is a problem. Furthermore, the temperature needed in fission reactors is of the same order of magnitude as in the solar core and causes serious problems in the control of fission as also the Fukushima accident demonstrated.

   Small scale fission power planets are not so dangers and work is done to develop applications in which nuclear power would be produced in small scale.

2. Second option is fusion of light nuclei, which liberates energy for nuclei lighter than iron (Fe). Also the temperature prevailing in the solar core is needed. Now the problem is plasma confinement. Magnetic bottle is the basic solution but it has instabilities: for instance magnetic bottle tends to develop a pinch. Fusion plants still do not exist despite the research which has lasted more than seven decades (`https://en.wikipedia.org/wiki/Fusion_power`).

3. The third option is non-orthodox and would be based on "cold fusion" (CF), which was reported already 1920 and 1989 by Pons ja Fleischman. Mainstream physics has had a hostile attitude to CF as becomes clear from the ultra-skeptic Wikipedia article `http://tinyurl.com/8lkm6eq`) but gradually the attitude has changed and CF researchers are taken seriously.

   On basis of recent understanding one can say that CF is not a proper term. Ordinary fusion cannot be in question already because it is not possible at low temperatures and because the distributions of heavier isotopes do not correspond to those assignable to ordinary fusion. Low energy nuclear reactions (LENR) or nuclear transmutations are slightly better terms. In the sequel I will use the term CF keeping however in mind that the term is only a convention.

   The book about the history of CF written by Krivit and having 3 parts [C8, C7, C9] (`http://stevenbkrivit.com` ,`http://tinyurl.com/y7tsoweh`, `http://tinyurl.com/rcfokn5`) provides a good overview about the situation.

To my opinion the basic problem of CF research is that theoretical understanding is missing so that the attempts to develop a technology are like searching a needle in haystack. Of course, the hostile attitude of the mainstream is second problem. The situation is not made easier by two optimistic promises in order to get funding and the underrating of theoretical understanding. Part of the problem is that the goal is to produce energy although at this stage the main emphasis should be on the understanding of the phenomenon.

1.1.2 Could TGD have something to give?

My own goal has been to develop theoretical understanding about CF and also about nuclear physics on basis of the new physics predicted by Topological Geometrodynamics (TGD) [K11] (`http://tinyurl.com/zrx5mdz`, `http://www.tgdtheory.fi/tgdarticlesall.html`), which can be can be regarded as my lifework hitherto. In the sequel I try to summarize this work in hope that it could help to invent the desired new technology.

The following gies a very brief summary about tGD.

1. TGD leads to an identification of dark matter as phases of ordinary matter with non-standard value $h_{eff} = n \times h_0$ of effective Planck constant, which make possible quantum coherence in arbitrarily long length scales proportional to h_{eff}. The hypothesis follows from a generalization of physics to describe correlates of cognition: number theory becomes an essental part of quantum physics [L9, L10].

2. This leads to a model of quantum biology [L14]. The coherence of living matter is the basic problem of biology: biochemistry cannot explain it. The basic problem of standard quantum biology is in turn the smallness of the ordinary Planck constant h - it is very difficult to understand the coherence of living matter as macroscopic quantum coherence. TGD would solve this problem: dark matter with genuine quantum coherence in long scales would induce coherence of ordinary matter (not quantum coherence anymore).

   Dark matter in TGD sense would provide also a starting point for the attempts to understand photosynthesis, which is now believed to involve quantum physics in an essential manner. The mimicry of the photosynthesis at the level of technology would be an alternative new energy technology.

3. Dark nuclei would be in central role in the proposed model of CF [K13], which would reduce to the production of dark nuclei by feeding to the system energy increasing the value of h_{eff}. Dark nuclei for which the binding energies of basic build blocks would be very small, would decay to ordinary nuclei and liberate energy as in ordinary nuclear fusion. The key question considered is of course what dark nuclei precisely are.

   This leads also to a proposal for a theory of nuclear physics, which could replace the nuclear models, which typically explain only some aspects of nuclear physics. The birth of dark nuclei in the collisions of nuclei would replace the tunnelling phenomenon, which reduces the value of energy above which the nuclear reactions can take place from its classical estimate by factor of order 1/100. Because the energy of dark states increases with h_{eff}, this would require high collision energy and high temperature in hot fusion.

4. In CF the production of dark nuclei would require only a relatively small energy because the building bricks of dark nuclei would be free protons, deuterons, perhaps even heavier nuclei for which one would not do anything. They would form dark nuclei as string like entities assignable to flux tubes and the binding energy for the interaction between basic building bricks would be much smaller than that in ordinary nuclei and assignable to flux tube bonds between them. The increase of h_{eff} to produce dark nuclei from - say - deuterons would require only a small energy because the binding energy of dark nucleus would reduce the needed energy. For instance, laser beam could be enough as the researchers like Holmlid indeed claim [L6].

   After this the dark nuclei could transform spontaneously to ordinary nuclei in the transition $h_{eff} \to h = 6h_0$ and liberate energy which is of the same order of magnitude as the binding energy of ordinary nuclei. Dark nuclei can also react - as in ordinary hot fusion - before the transformation to ordinary nuclei.

   One can say, that in CF one goes to the edge of the energy cliff and jumps down. In hot fusion one jumps from the bottom to te edge and then jumps down.

5. The basic mechanism of CF and also ordinary fusion would be rely on quantum coherence provided by large h_{eff}; the notion of magnetic flux tube; quantum criticality (QC) of TGD Universe making possible flux tube contacts of small energy between reactants with various lengths as analog of long range fluctuations (this would break the limitation due to the short range of nuclear forces and Coulomb wall); the breaking of QC induced by increase of length scale dependent cosmological constant Λ for flux tubes predicted by twistor lift of TGD [L11] increasing their string tension so that the resulting force attracts reactants together and allows to overcome the Coulomb wall so that reaction can proceed: the shortening of flux tube would however involved temporary reduction of h_{eff}.

   The energy to increase Λ and string tension for the flux tube energy would come from reactant: essentially analog of metabolic energy provided by reactants would be in question. The mechanism is basically the same as in bio-catalysis [L14], where the energy wall hindering the reactions corresponds to Coulomb wall.

Energy production would not be the only application of CF. Modern technology needs various elements such as metals and there is a shortage of these. CF might allow to produce these elements in industrial scale. Also in quantum biology dark matter and dark nuclei - albeit in different scale as compared to CF - are in central role (`http://tinyurl.com/yyyk6fu8`), and might provide a theoretical basis for developing artificial photosynthesis.

Monochromatic lines around .5 MeV and 3.5-keV X rays have no standard identification. The recent findings [E2] exclude the possibility that these particles reside in the conjectured galactic dark matter halo. The detailed consideration of these findings led to an unexpected further progress in TGD based vision about nuclear physics developed in the first version of this article. A correct prediction for the energy of 3.5 eV line emerges and also the .5 MeV line is predicted correctly in terms of TGD based nuclear physics.

CVC and PCAC hypothesis, $M^8 - H$ duality, and p-adic length scale hypothesis support the view that hadron and nuclear physics could allow a description dual to QCD like picture in terms scaled down weak interaction physics. This picture finds concrete quantitative support. Several p-adic length scales would be involved and the active scale would depend on interaction energy. In particular, a pseudoscalar having interpretation as X boson with mass about 17 MeV is also predicted.

2 Short summary about the history of CF and about its problems

In the sequel short summary about the history of CF is given and also objections against are discussed.

2.1 About the history of CF

Krivit has written a book with three parts about CF [C8, C7, C9] (http://stevenbkrivit.com ,http://tinyurl.com/y7tsoweh, http://tinyurl.com/rcfokn5). The book gives a good overall view about a good overall view about the history of CF. I have written an article about the book in [L8] (http://tinyurl.com/y7u5v7j4). I have considered CF also from a wider perspective [K13] (http://tinyurl.com/y2v3qn6a.

CF (http://tinyurl.com/8lkm6eq) has been discovered several times during the previous century.

1. Thomas Graham observed the ability of Pd to absorb hydrogen already at 18th century. 1920 Paneth and Peters reported transmutation of hydrogen to helium as it was absorbed in a thin Pd at room temperature. Later they however ended up to the conclusion that ^{4}He was due to the background in the air.

2. 1927 Tandberg reported fusion of of hydrogen to He in electrolysis using Pd electrolyte and applied for a patent: patent application was rejected since Paneth and Peters had concluded that fusion is not in question. Tandberg did also experiments with heavy water after the discovery of deuterium (D) in 1932, and the experimental arrangement was similar to that used by Fleischman ja Pons, who were not aware of these experiments.

3. Fleischman ja Pons reported CF in 1989. The observations raised a wide interest but the negative attitude of nuclear physicists killed the interest although a small group of researchers continued to study the phenomenon.

   Fleischman ja Pons used Pd as elektrode ja heavy water as electrolyte. The experiments lasted for weeks. The temperature used was 30 ∘C. In the beginning of the run the output power as given by calorimeter was same as the input power. At some stage the temperature was suddenly raised to 50 ∘C without changes in the input power. This perio lasted for several days and repeated several times during the same run. Eventually these periods were not detected anymore.

4. CF research continued despite the fact that CF researchers became the pariah of science community. Japanese researcher Mizuno is one of the researchers taken seriously [C5]. The DOE panel in 2004 changed the situation: one can say that CF researchers were taken as normal human beings.

   In 2004 APS allow CF sessions in APS conferences. ACS followed in 2007. A new turn appeared when emeritus professor Holmlid from Island was invited to APS conference to talk about his observations.

   As far as I know, CF is under commercial development behind the scene. Quite recently an Australian startup group HB11 (http://tinyurl.com/tbloqfw) claimed that it can produce CF by using a very simple arrangement using HB11 pellets in a reactor volume and two laser beams. The first beam would be responsible for magnetic confinement and second wo would induce the compression of the pellets making possible fusion (this resembles the situation in Holmlid's experiments).

Also biofusion has been reported [C1, C10]. For instance, Ca would emerge in living organisms through nuclear transmutations. This brings in a new interesting aspect to the problem.

2.2 Key objections against CF

What are the key counter arguments against CF?

1. Pons ja Fleischman reported a detection of also neutrons and tritium in their experiments. Also gamma radiation predicted by ordinary fusion to ^4He was reported. These observations did not find support. The production of also heavier isotopes has been reported as also X rays.

2. Second objection is poor replicability but already the experiments of Pons ja Fleischman suggested that the phenomenon in question is critical - maybe even quantum critical - and appears therefore only at critical values of controllable parameters. That water does not freeze in 50 ° C at normal pressure does not mean that it does not freeze at all. CF could occur only whether the density of deuterium in the target is in critical range, and one can think that the repeated heat production periods correspond to the gradual stepwise penetration of D deeper to the Pd target and reaching of the critical surface density at the inner surface of the porous Pd.

3. The theoretical objection against CF is that it is no energetically possible: this would be due to the Coulomb wall requiring temperatures of order million Kelvins. Also the failure to observe the production of neutrons, tritium and ^{3}He is in conflict with ordinary fusion. CF cannot be in question and if the phenomenon is real, new physics is involved, and this option the nuclear physicists are not ready to consider.

What makes the situation intersting that already 10 years ago Asplund et al observed a possible anomaly in the nuclear physics of solar core [E1, E3]. This suggests that even hot fusion and nuclear physics itself is not completely understood. What was observed was that the nuclear abundances at the surface of Sun deduced from helioseismic waves and solar neutrino data were considerably higher than those deduced from the spectroscopy at photosphere and from meteorites.

Second anomaly is older. The X rays arriving from Sun have energy scale of keV. It has been found that the annual variation of the X ray intensity due to the variation of the Earth-Sun distance causes a similar variation in the rates of nuclear decays [C3]. This would suggests new nuclear physics in keV scale. Atomic nuclei would have excitations in the energy scale of keV.

What are the basic problems besides the above mentioned problems. Perhaps the worst sociological problem is reductionistic approach, which does not allow mainstream physicists to consider seriously the possibility of new physics. This would violate the belief about the glorious march of the physics towards shorter and shorter length scales. Ironically, the last step - super string models - was meant to take us directly to Planck length scale, but the outcome was a failure, which also forces to challenge the reductionistic dogma. The fact after all is that theoretical nuclear physics is a collection of models, which are more or less in harmony.

For instance, tunneling phenomenon plays a central role in the model for nuclear reactions. It makes possible reactions at temperatures which are by a factor 1/100 lower than the energy defined by Coulomb wall and energy of nuclear reactions (about 1 MeV). Coulomb wall is basic concept determined from the Coulomb potential for the nucleus and from the phenomenological potential describing strong interaction energy. The parameters of this potential are chosen so that the energy for the onset of nuclear fusion is reproduced. The models in general treat nucleons a point like objects, which are non-relativistic. A real theory of nuclear interactions is lacking.

3 Why TGD and what TGD is?

The following gives a brief overview about the motivations and basic ideans behind Topological Geometrodynamics (TGD) [K11] [L14, L24].

3.1 TGD as a solution to the energy problem of general relativity and as a generalization of super-string models

The space-time of general relativity theory (GRT) is a metric deformation of Minkowski space M^4, which is the space-time of special relativity. M^4 is flat and corresponds to empty space-time. The deformation makes it curved. The basic postulate of GRT is that the presence of matter makes space-time curved and Einstein's equations describe what this means mathematically. I this deformation however the symmetries of M^4 - Poincare invariance - are lost. Noether's theorem states that every symmetry corresponds to a conservation law. Now the laws for conservation of energy, momentum and angular momentum are lost.

One could argue, that the loss is not fatal because gravitation is extremely weak interaction. One the other hand, it as infinitely long range and is not screened like electromagnetism and color interactions. Also the attempts to quantied GRT have failed. The probably reason is that the

predictions of quantum field theory are coded by S-matrix defined by using Hamilton operator, which corresponds to conserved energy, and does not exist mathematically in GRT.

Perhaps superstring theory was a mathematical success because the 2-D orbit of string was a 2-surface in 10-D space-time having 10-D Poincare symmetries. Space-time is however not 2-D so that the model is unrealistic in this sense. Also spontaneous compactification as a 10-D modification of 4-D space-time having 6 small dimensions was highly non-unique and led to landscape catastrophe and the predictability was completely lost.

The proposed solution can be seen as a generalization of string models. One replaces 2-D string world sheets with 4-D space-time surfaces interpreted as orbits of 3-D particles in some higher-D space-time $H = M^4 \times S$, so that the symmetries of M^4 and space S are symmetries of the theory and classical conservation laws are not lost. If one assumes $S = CP_2$, one obtains the symmetries of standard model and a geometrization of both gravitation and standard model interactions: the dream of Einstein would be realized in terms of sub-manifold geometry.

It turns out that $H = M^4 \times CP_2$ is a unique choice also mathematically. If one requires that TGD allows "twistor lift" replacing space-time surfaces with analogs of their 6-D twistor twistor spaces in the 6+6-D product $T(M^4) \times T(CP_2)$ of twistor spaces of M^4 and S, then M^4 and $S = CP_2$ are the only possible choices since they allow twistor spaces with Kähler structure, necessary for the formulation of the twistor lift [A1].

3.1.1 New view about space-time

TGD leads to a new view about space-time. Space-time is 4-D surface in space which can be obtained from empty Minkowski space M^4 by replacing its points with CP_2. The size of CP_2 is extremely small, roughly noin 10,000 kertaa Planck length. A convenient lower-dimensional analogy is glass plate whose thickness is of this order of magnitude. The analog of Einsteinian space-time is 4-surface for which M^4 projection is 4-dimensional. One could but this kind of surfaces on top of each other - obviously they are are extremely near to each other. These space-time sheets can be connected by extremely small wormhole contacts, which one sees as illustrations in popular books about GRT. I call this structure many-sheeted space-time.

The general solution of field equations for twistor lift is minimal surface having 2-D surface as singularities as singularities: these 2-D surfaces have interpretation as string world sheets and partonic 2-surfaces as I call them [L4, L20]. In geometrodynamics minimal surface property becomes the geometric counterpart for the masslessness of field. Stringy world sheets are analogous to the source of massless fields (charge densities) and the analog of string model is obtained if one leaves only these sources under consideration. One can associated to the ends of strings fundamental fermions as point-like entities and build from these elementary particles.

One obtains several solution types as simple limiting cases.

1. An important Einsteinian solution type is "massless extremal" (ME) [K12, K6], which corresponds to a radiation field consisting of analogs of plane waves propagating with light-velocity to single direction so that the shape of pulse is preserved. The solution is tube like structure with cross section having cylinder as 3-D projection. Laser beam is a good physical analogy. The linear superposition of Maxwell's equations is reduced to superposition of waves propagating in the same direction.

2. One obtains also non-Einsteinian space-time surfaces for which M^4 projection has dimension lower than 4 [K12].

   (a) If the projection is 1-D light-like geodesic line one obtains CP_2 type extremal providing a topological model of elementary particle.

   (b) If the projection is 2-D string world sheet, one obtains 4-D objects looking like string world sheet. I call this object cosmic string. Its deformations have in general 4-D M^4 projection which finite thickness. I call these deformations magnetic flux tubes.

   Magnetic flux tubes turn out be central objects in all length scales: the reason is that quite generally length scale reductionism, is replaced by fractality in all length scales. Cosmic strings dominate very early cosmology and galaxies are local tangles for the cosmic strings at which it thickes to flux tube. Also stars and planets are this kind

of structures. One can talk about flux tube spaghetti [L17]. These flux tubes are also basic building brickes of hadrons, atomic nuclei, molecular bonds and biomolecules.

3.1.2 The new view about fields and the notion of field/magnetic body

There is no need to assume bosonic gauge fields of standard model and gravitational field as primary dynamical variables. When one knows the space-time surface, one knows all the fields of standard and also gravitational field determined by the induced metric. Geometrization of gauge potentials and - fields reduce to the induction of spinor structure so that the dream of Einstein is fulfilled.

Fundamental fermions appear in the role of fields and for the simplest option only quark fields of single fermion generation are needed [L23]. Leptons can be build as local composites of 3 quarks and baryons as their non-local composites. This means a new view about supersymmetry: LHC indeed excluded the standard proposal for what SUSY could mean at LHC energies where it was well-motivated. This leas also to a generalization of super-space: many-fermion states as quantum Boolean logic identified as "square root" of Kähler geometry: the super-analog of space-time surface in TGD sense would realize this idea concretely.

In many-sheeted space-time the classical fields associated with a given system correspond to space-time sheets carrying them: magnetic and electric fux tubes and radiation fields described by massless extremals. Many-sheetedness brings in new elements. Tue to the extreme non-linearity of field equations, the superposition of field is in general not possible but test particle as small 3-space-time surface - wormhole contact - touches all space-time surfaces having projection to given M^4 region and experiences the sum of their effects.

In Maxwellian theory this observation leads to the postulate that there exist fields, which superpose. In TGD one returns to the roots and does not assume this at fundamental level. At the quantum field theory limit of TGD one replaces many-sheeted space-time with a region of M^4 and identifies gauge potentials and the deviation of induced metric from induced metric with the sums of the corresponding induced quantities for space-time sheets.

The field carrying space-time sheets associated different systems are in general separate although they can have tiny wormhole contacts -they touching). Wormhole contacts can also serve as topological representations of elementary particles. In the wormhole contact the Minkowskian signature of space-time sheet (1 time like dimension) becomes Euclidian (all dimensions are space-like) The M^4 projection of wormhole contact is however light-like curve.

One can say that any system has field identity - field body. As a special case one can speak about magnetic body having as body parts magnetic flux tubes and - sheets. The notion of magnetic boy is central in TGD inspired quantum biology and actually in entire TGD.

3.2 Number theoretic physics, hierarchy of effective Planck constants, and dark matter

An important input in the development of TGD were p-adic mass calculations [K10]. The masses of elementary particles are still a mystery in mainstream physica and in standard model Higgs mechanism provides a parameterization of fermion massess: their values are fed in as couplings of Higgs f to fermions so that nothing is actually predicted.

p-Adinen thermodynamics as a generalization of standard thermodynamics - mass square replaces energy - describes particle masses as thermal masses [K1, K3]. Massless particle is mixed with its very massive excitations so that one obtains massivation. Higgs does not produce the massivation although it belongs to particle spectrum as also pseudoscalar as its partner.

The success of p-adic mass calculations led to the question, whether p-adic physics for various primes p, could be a part of TGD.

1. All p-adic number fields must be allowed, which suggests that forms from real numbers and various p-adic number fields a book-like structure. The pages of thes book would intersect at points which can be regarded as number common to reals and all p-adic number fields. Rationals are these points [L9, L10].

2. Also the extensions of p-adic number fields are possible. Every extension of rationals defines such an extension. Algebraic extensions of rationals obtained in terms of the roots of irre-

ducible polynomials induce extensions of p-adic number fields One obtains infinite number of adelic books with back consisting of the numbers in the extension forming an entire library.

3. This picture generalizes at the level of space-time surfaces. Adelic space-time surface has infinite number of pages labelled by reals and by extensions of p-adic number fields defined by extensions of rationals. They obey formally same field equations. Number theoretical universality states that the solutions have the same form independently of the number field.

What could be the interpretation of this structure.

1. p-Adic physics differs from real physics that the solutions of field equations are not completely deterministic. For instance, the integration constants of equations of motion have vanishing derivative as in real case but this implies only that they are piecewise constants.

   In TGD inspired theory of consciousness one must ask what are the space-time correlates for sensory percepts, cognition, intentionality, and imagination. Could p-adic non-determinism correspond to the non-determinism of imagination?

2. If one accepts number theoretical universality, one can ask whether p-adic space-time surface interpreted as an imagined time evolution - intention - is realistic only if the pseudo constants are genuine constants so that p-adic space-time surface defines also real counterpart. If this is not the case, then only a part of p-adic space-time surface would correspond to real space-time surface - "reality". In neuroscience imagined sensory percepts and motor action indeed look like partially realized perceptions and motor activities.

The algebraic extensions of rationals form a hierarchy. The higher the dimensio n of the extension (degree of irreducible polynomial) is, the higher the algebraic complexity. A natural interpretation would be as an evolutionary level. In quantum jumps the dimension of the extension is bound to increase in statistical sense: this would correspond to evolution.

It turns out, that the dimension n corresponds naturally to effective Planck constant $h_{eff} = nh_0$, where h_0 is the smallest possible value of h_{eff}. Ordinary Planck constant can be argued to be equal to $h = 6h_0$ [K14] [L5, L13, L29]. The higher the evolutionary level, the longer the scale of quantum coherence proportional to h_{eff}. A natural guess is that the origin of the coherence of living matter is here.

p-Adic primes label elementary particles in p-adic thermodynamics (for instance, electron corresponds to Mersenne prme $M_{127} = 2^{107} - 1$). Also for more general systems p-adic prime characterizes the size scale of the corresponding space-time sheet. What could be the number theoretical identification of the p-adic primes in terms of extension of rationals?

1. One can assign to each algebraic extension of rationals so called "ramified" primes. Their number is finite. Could they characterize the particles and systems assignable with the extension [L15, L18, L25]?

2. On the other hand, the dimension n of the extension has a product decomposition to powers of primes, and it turns out that these primes play a central role in "small" state function reductions as analogs of weak measurement producing as a by-product a physical correlated for the decomposition of n to powers of primes [L30].

Which identification is correct, is better to leaven open but my personal guess is that the first option is the correct guess.

3.3 Quantum measurement theory based on zero energy ontology and theory of consciousness

Quantum measurement theory is the black sheep of quantum physics: the problem is that Schrödinger equations is deterministic but state function reduction is not so that the the theory has internal contradiction. TGD based quantum measurement theory based on what I call zero energy ontology (ZEO), solves this problem.

The basic geometric notion of ZEO is causal diamond (CD) [K9] [L12, L22].

1. The causal diamond of M^4 - call it cd - is the intersection of the future and past directed light-cones and is therefore 4-D. CD is obtained from cd by replacing its points with CP_2 and is therefore 8-D. In TGD visualization cd would be diamond in 2-D Minkowski space M^2.

2. CD sizes (cd sizes) form a hierarchy. Number theoretic arguments suggest that the temporal distance between the tips of CD is multiple of CP_2:n size scale (divided by c). CDs can contain sub-CDs. Sub-CDs would correspond to mental images of conscious entity - "self" - assignable to CD. Sub-sub-CDs would not correspond to separate mental images but a kind of average.

3. The geometry of CD should be understood also from this point of view. CD receivers sensory information from environment- exterior of CD. It would arrive from the geometric past of CD and the shape of CD is ideal in this respect. When the arrow of time changes in "big" state function reduction (BSFR) the former geometric future becomes geometric past and sensory information arrives also from geometric future in standard sense.

4. The input from the interior of CD - from the lower end of CD - corresponds to the information of conscious entity from its 4-D body. Also now the situation depends on the arrow of time.

ZEO based quantum measurement theory leads naturally to theory of consciousness, when "small" state function reductions (SSFRs) as analogous of "weak" measurements (`http://tinyurl.com/zt36hpb`) are identified as moments of consciousness, looks like follows.

1. In ZEO quantum zero energy states are identified superpositions of entire deterministic time evolutions as analogs of Bohr orbits. The act of free will is analogus to the starting of deterministic computer program. One selects some sub-program from a menu and starts it by clicking the icon. This is what our behavior mostly is, selections between a menu of routines.

   The routines correspond to a hierarchy space-time sheets, CDS, and of selves. The program starts in long time time scale T_{max} and implies starting of programs in shorter time scales a $T_1 < T_{max}$ ... The process from top to bottom as a cascade.

2. In ZEO one can distinguish between two kinds of state function reductions (SFRs).

   (a) "Small" SFRs (SSFRs) correspond to "weak" measurements (`http://tinyurl.com/zt36hpb`). The arrow of time does not change and and the members at the active boundary of CD changes and also the distance between the tips of CD clock time in very general sense - increases in statistical sense. The states at the passive boundary of CD are unaffected by change at the active boundary. One can say that generalized Zeno effect is in question.

   (b) "Big" (ordinary) SFR (BSFR) changes the arrow of time at magnetic body (MB) in long length scales - this induces effective change of the arrow of time at the level of ordinary matter. BSFs can change the arrow of time also at the level of ordinary matter but this happens in so short time scales that it is interpreted in terms of dissipation and second law.

   Libet's findings can be explained and they provide that free will corresponds to BSFR in macroscopic scale. The act of freed will, BSFR, changes the arrow of time and thus the arrow of causality and one can say that the final state of BSFR causes at the classical level the neural activity in geometric past (classical physics is an exact part of quantum physics in TGD). The observed has opposite time direction and it seems that the neural activity causes the experience of free will: this gives rise to the paradox.

3. The real surprise came as I developed a concrete model for the contents of consciousness of self [L30]. The basic question is: What the moment "Now" corresponds geometrically. The surprise was that "Now" seems to correspond to the time=constant M^4 hyperplane corresponding to the maximal radius of cd. This corresponds to $t = constant$ snapshot in the middle of CD, where t linear M^4 time coordinate such that time axis connects the tips of CD.

At passive boundary of CD the members of state pairs forming zero energy states remain unaffected during SSFRs. Also passive boundary itself remains stationary except that its size increases with that of CD.

Because the active upper boundary at which the members of state pairs state pairs change in time evolution by SFRS shifts to the direction of geometric future in statistical sense, the moments of consciousness experienced earlier move to the direction of geometric future ($M^8 - H$ duality allows to formulate this precisely [L19, L22])! Information theoretically this means that the "personal history" of self is stored to the active boundary of CD! In the second re-incarnation with reversed arrow of time this information forms the permanent part of self, "soul" one might say. Naive expectation would have been that personal memories are located in the geometric past! Only the sensory input from external world and from the body of self as CD would be from the geometric past. This picture would realize mathematically the belief called Karma's law.

What about the experimental support? Last summer I learned about the observations reported by Minev et al [L16] providing a strong support for ZEO at the level of atomic physics [L16] (`http://tinyurl.com/yj9prkho`).

1. Contrary to expectations it seem that state function reduction (BSFR) corresponds to a continuous deterministic time evolution leading to the final state of reduction rather than instantaneous and discontinuous quantum jump.

   ZEO explains this naturally. Quantum jump occurs instantaneously in the sense of subjective time but the final state corresponds to a superposition of classical time evolution from final state to the geometric past. The assumption that the time arrow of time is that of the experimenter creates the illusion that time evolution leads to the final state. This is only one example of causal anomalies predicted by ZEO.

2. It was also found, that even when one removed the stimulus inducing the quantum jumps, the time evolution that had already started, ledt o the final state.

   The ZEO explanation is that quantum jump had already occurred.

3. If one modified stimulation, the time evolution stopped.

   In ZEO this can be understood if the modified stimulus induced opposite quantum jump.

Libet's experiments relating to the active aspect of consciousness [J1] demonstrated, that the experience of free will was preceded (in the sense of geometric time) by neural activity in brain so that free will would be an illusion in standard ontology. In ZEO the interpretation would be that the arrow of causality change: the act of free will caused the neural activity in the brain of geometric past.

3.4 The new view about quantum biology

Number theoretical vision and ZEO lead to a model of quantum biology. Perhaps the key challenge of biology is the understanding of coherence of living mater. The vision about life as mere biochemistry does not explain the coherence since coherence lengths i biology are of the order of molecular size scale.

1. The natural idea is that dark matter as phases of ordinary matter characterized by the value $h_{eff} = n \times h_0$ of the effective Planck constant, produces the coherence of ordinary living matter somehow. The dark matter would reside at magnetic body (MB). The coherence at biological body (BB) would not be quantum coherence but coherence induced by MB. The coherence scale at MB - in the simplest situation proportional toh_{eff} - would produce at the level of BB.

2. Dark matter hierarchy would correspond to evolutionary hierarchy and evolution would be unavoidable.

Metabolism and self-organization are essential aspects of biology.

1. Self-organization require energy feed. In biology this means metabolic energy feed and nutrient molecules serve as storages of metabolic energy making possible the extraction of energy.

2. An important consequence of ZE is that the aspect of ZEO corresponding to buildup of new structures can be seen as dissipation in non-standard arrow of time implied by a generalization of second. In standard direction of time one sees generation of structures and gradients - in particular temperature differences - instead of their decay. Enormous number of specific mechanisms becomes un-necessary. One can also say that apparently the system extracts energy from the environment rather than serving as a passive receiver.

   Motor activity serves as a basic example. It would correspond to BSFRs whereas sensory activity would correspond to SSFRs. In notor activity as BSFR brain only apparently generates signals inducing motor activity.

3. One problem of standard ontology is that it is very difficult to understand how living matter can react so rapidly. The nerve pulses between brain and muscles are slow and multiple feedback would be needed to the fine adjustment of motor activity. Someone has estimated that the process in which cat gets frightened so that its hair raises, would take time of order of the age of the Universe. Penrose discussed the reaction of tennis player to the approaching tennis ball as an example of this.

   ZEO solve this problem. The activities which should precede the reaction due to frightening has led to the final state and the processes that would precede it in standard ontology take place in non-standard time direction. One could also say that the reaction starts already in geometric past and is initiated by signals proceeding into geometric past. No separate mechanism are needed: it is enough to have stored metabolic energy and proteins take care of this.

ZEO and dark matter at MB allow also to understand why the biomolecules participating to bio-catalysis are able to find each other and why the bio-catalysis so extremely effective.

4 TGD based model for CF

Coulomb wall is the basic problem of CF. Also the fractions of the produced nuclear isotopes differ from those predicted by fusion and gamma rays seems to be missing. X rays have been however reported.

4.1 Nuclear string model

For more than two decades ago I proposed that in TGD Universe ordinary nuclei could correspond to nuclear strings [K18, L1].

1. Nuclear strings would be magnetic monopole flux tubes (not possible in Maxwellian world) at which nucleons and the stable units formed from the (deuterium, ^4He at least) condense. There would be hierarchy of flux tube within flux tubes. The radius R of flux tubes would be of the order of proton Compton length. Basic units would have a distance of order of the distance between nucleons. The basic units would be connected by meson-like flux tubes having quark and antiquark at their ends. The simplest assumption is that the flux tubes are color singlest and masses are much lower than those of ordinary mesons and even lower than about MeV energy scale for nuclear energies. keV energy scale was proposed on basis of the observed anomalies. They could correspond to a scaled down version of hadron physics such that pion has mass scale is of order of keV.

2. In standard picture the strong isospins of proton and neutron are opposite and p-n pairs have attractive interaction energy. In the harmonic oscillator model of nuclei, this kind of pairing is assumed. What could it correspond at the level of nuclear strings? Do proton and neutrons form pairs - deuterons - in such a manner that the distances between surplus neutrons or protons are maximized. Or does one have helical pairing of proton and neutron flux tubes such that neighboring p and n are paired?: this would be analogous to base pairing by hydrogen bonds taking place in DNA double strand.

3. ^{4}He is also a stable nucleus for which neutron and proton numbers are same. Could one imagine fractal structure consisting of flux tubes within flux tubes. ^{4}He flux tube would consist of 2 D flux tubes, and one could build flux tubes containing closed ^{4}He flux tubes. Also heavier nuclei allow stable isotopes for which proton and neutron numbers are same and one cannot exclude the possibility that even these could form nuclear strings. Also DNA double strand has this kind of coils-within-coils structure and I have proposed similar mechanism at the level of associated magnetic flux tubes.

Quite recently considerable progress took place as I learned observation suggesting a new particle, whose quantum numbers are those of pion and also mass is not too far from pion mass. The new particle does not fit in standard model. One can find a popular article about the discovery in Scitechdaily (`http://tinyurl.com/wb98u6u`) and an article in Phys Rev Letters (`http://tinyurl.com/v2rwh3e`).

1. The observation was not actually new. For years ago Tatitcheff ja Gustafson reported that pion seems to have what they called "infrared" (IR) Regge trajectory, in fact several of them. There would be states at least with the masses 60, 80, 100, 140, 181, 198, 215, 227.5, ja 235 MeV. The value of string tension deduced from the mass difference of 40 MeV:n is in good approximation $T(\pi) = .01$ GeV^2 and corresponds to a mass about 100 MeV, which is mach smaller than the hadronic string about $T_H = 1$ GeV^2 assignable to color magnetic flux tubes. TGD predict a p-adic hierarchy of magnetic flux tubes characterized by string tension.

2. Could $T(\pi)$ be associated with the interactions of atomic nuclei? Surprisingly, the energy scale associated with the nuclear excitations would be about 5.1 MeV, which is smaller but of same order of magnitude thatn the electromagnetic energy scale determined by Coulomb energy for nucleus, which is is of the order 7.8 MeV ($\alpha\hbar/R$, R is the radius of nucleus of order .1 fm). This energy scale is same as that for the atomic binding energies for ^4H and heavier nuclei.

3. One can ask whether the string tensio is same for (possibly em) flux tubes for nucleons as for for pion. Nucleus corresponds to p-adic length scale $p \simeq 2^k$, $k = 113$ and scaled down hadronic string tension $T(\pi) = T_H/64$. The corresponding energy scale would be 7.8 MeV. If nucleons correspond to $n \geq 0$, it can happen that in atomic nucleus the value of n for nucleons is smaller than for free nucleons: this could allow an elegant explanation for nuclear binding energies by reducing them to the level of magnetic body of nucleon.

4. The harmonic oscillator model of nuclei would be replaced with a model in which the excitation energies of nuclei would be of the sam form as those of oscillator model in the approximation in which the mass scale determined by string tension is smaller than the mass of nucleon. Because there are three flux tubes associated with nucleon consisting of 3 quarks, nucleon behaves effectively like 3-D harmonic oscillator. The nucleons of the nuclear string are in good approximation free so that the model resembles strongly harmonic oscillator model. Nuclear physics would reduce in good approximation to single nucleon level - or more precisely, to the level of magnetic body of nucleon: Hartfree-Fock philosophy would be completely wrong! It would be possible to understand that behavior of nuclear binding energies in a rather detailed manner as a function of charge and mass number [L27] [K4].

5. What is the energy scale of the flux tube pairs? If the neighboring nucleons are connected by a flux tube the flux tube must correspond to an energy scale considerably lower than MeV scale of nuclear binding energies. X ray radiation having energy scale of order keV has anomalous effects on nuclei. For instance, the decay rates of nuclei have been reported to depend on how intense the X ray radiation arriving from Sun is: the intensity varies with Earth-Sun distance [C3].

   This has motivated the earlier proposal that the energy scale for the flux tubes is of order keV. If color magnetic flux tube is in question - perhaps p-adically scaled down pionic flux tube could be in question - the p-adic length scale would be of the order of electron Compton length. MeV scale would scale down by a factor $m_e/mp \simeq 2^{-11}$. Also em flux tube could be in question.

On the other hand, the model of cold fusion and of also nuclear fusion based on the observations of Pollack ja Holmlid suggests that the energy scale e_B for the flux tubes connecting dar protons/D-nuclei is about eV and therefore the basic energy scale of biology. This would suggest that keV is the energy scale for the flux tubes connecting nucleons in ordinary nuclei, and e_B corresponds to energy scale for flux loops assignable to nucleons and is the energy scale for secondary IR Regge trajectories.

4.2 Pollack effect

Pollack effect [L2] [L2] was one of the first empirical inputs of the model of CF.

1. Pollack effect is observed when water bounded by gel is irradiated using for instance IR radiation. Also other wave lengths can be used and it has been argued that almost energy energy feed works. What happens is charge separation: a negatively charged region -exclusion zone (EZ) - is formed near the boundary of gel and water phase: part of protons goes somewhere. Stoichiometrically one has $H_{1.5}O$ molecules and they form a structure formed from hexagonal 2-D layers. EZ is thermodynamically anomalous. It excludes various impurities which is in conflict with second law predicting that concentration gradients disappear. Also charge separation can be seen as a thermodynamical anomaly.

2. The TGD based interpretation is that protons transform to dark protons and go to magnetic flux tubes, where they form sequences, dark nuclei. Energy feed is needed to increase h_{eff} since the energy of the system quite generally increases with h_{eff} with other parameters kept constant. This is essentially metabolic energy. One can argue that the Coulomb repulsion of protons is compensated by dark interaction energy, which is of order keV, if binding energy scales down like $1/h_{eff}$. Here one must be however cautious since the energy assignable to flux tube is expected to scale like h_{eff} and the energy in question would correspond to the energy assignable to the bonds connecting protons rather than ordinary nuclear binding energy.

   The quantum states of dark proton triplets can be classified to 4 types and the numbers of states in these classes correspond to the numbers of DNA, RNA, tRNA, and amino-acids. Genetic code is realized in a simple manner and the number of dark DNAs coding for given dark amino-acid is same as in vertebrate genetic code. This inspires the idea that dark DNA and ordinary DNA are paired and that the distance of dark protons at the flux tube is of order nanometer as is also the distance of DNA codons at DNA strand. Dark genetic code would be the fundamental code and ordinary genetic code would represent its chemical mimicry. Binding energy for dark nucleon bond would scale down to eV scale correspond to the energy scale for the photons fed into the system.

3. These dark nuclei could also appear in the initial state of CF as also bio-fusion suggests. The radius and length of the flux tube can of course correspond to a p-adic length scale: I have proposed long time ago that transitions reducing h_{eff} to h and preserving flux tube thickness are possible [K7, K8, K2].

4. Zero energy ontology (ZEO) would explain thermodynamical anomalies associated with EZs. The arrow of time would change in BSFR at MB and induce effective reversal of the arrow of time at the level of BB.

The fact that the energy scale of Pollack effect is of order eV and the length of flux tubes is of order nm suggests that the string tension for them is rather small - of order $T \sim 10^{-3}$ eV^2. This and bio-fusion serve as hints in the attempts to understand CF.

1. Twistor lift of TGD [L11] predicts that the string tension T for flux tube corresponds to length scale dependent cosmological constant Λ. The length scale defined by it corresponds to the radius of the flux tube. T produces attractive force. There are reasons to assume that the length of flux tube is proportional to h_{eff} so that also the energy has this proportionality.

2. One could think that Pollack effect makes bio-fusion possible. $T \sim 10^{-3}$ eV^2 is rather small. If h_{eff} is large, then Λ must be correspondingly smaller so that small T is obtained. This value of T is quite too small to help protons over Coulomb wall.

   In bio-fusion protons must fuse together to ordinary nuclei and therefore near each other. One must overcome the Coulomb wall and this requires energy. Could the process start with a quantum jump increasing the value of Λ and therefore also the value of T. Either nucleus or both would provide the needed energy of order MeV to the flux tube! This would be somewhat like metabolism as energy change between proton and the MB, and would conform with TGD based view about pre-biotic biology [L14].

   The increase T would produce a force, which would attract the protons at the ends of the flux tube to each other and lead to the birth of ordinary nucleus.

   If h_{eff} decreases in steps the flux tube length decreases and protons receive the kinetic energy helping them to overcome the Coulomb wall. Also Λ must eventually decrease, which means that nucleon shifts back to normal state at its Regge trajectory.

3. The mechanism brings in bio-chemical catalysis in TGD based quantum biology. The value of h_{eff} and also the energy of the flux tube are large in the initial state. The energy of flux tube would come from metabolism by a quantum jump increasing Λ. Also now h_{eff} would decrease gradually and lead to a shortening of the flux tube and liberation of energy used to overcome the potential wall making the reaction slow. After the reaction the energy would be return in the ideal case.

4.3 The observations of Holmlid

The observations of Holmlid represent second empirical input [L6] [L6]. Holmlid has proposed a model for this observations, which served as an inspiration in the development of TGD based model [L8, L3].

1. Holmlid assumes that Rydberg atoms, which are atoms having one or more valence electrons at orbitals with large value of the principal quantum number N so that the radius of the corresponding Bohr orbit proportional to N^2 is very large.

   These valence electrons could be also dark since $h_{eff} = nh_0$ together with $h = 6h_0$ implies that $n = 6m$ electron at orbital N corresponds to Rydberg electron at orbital at orbital mN. One must however notice that in this case one obtains smaller number of values of orbital angular momentum so that the two options can be distinguished from each other. Also apparently fractional orbitals are possible corresponding to values of n not divisible by 6.

   How this could be significant from the point of view of CF? The production of dark nuclei requires energy feed to increase h_{eff}. Could the dark analogs of Rydberg atoms transform to ordinary ones by $h_{eff} \to h$ transition and liberate energy serving as "metabolic energy" in the generation of dark nuclei? Or could the energy feed using laser beam increase also the value of h_{eff} of dark valence electrons and generate dark variants of Rydberg atoms as a side product?

2. Holmlid uses laser beam (visible light) directed to Pd target containing D. He believes that laser produces ultradense phase, in which the distance between nuclei is of the order of Compton wave length of electron. He believes that this is enough to start nuclear fusion. The objection is that the creation of this kind of phase is energetically very difficult due to the Coulomb repulsion of protons. In TGD picture the binding energy of dark nuclei could come in rescue.

   Holmlid assumes that the ultra-dense phase is 3-D. In TGD it is enough to have 1-D phase corresponding to D nuclei at flux tube whose radius is of the orer of electron Compton length. h_{eff} would be of $h_{eff} = 2^{11}h$.

   Why 1-dimensionality would be so important? The creation of 1-D compression is easier using laser pulses. Furthermore, Coulomb energy for 1-D structure is proportional to the distance between the ends of the structure and would increase linearly with distance r unlike

in 3-D case, in which it behaves like $1/r$. Repulsive Coulomb energy thus contributes to string tension a term reducing it. Could this have meaning.

3. The fact that the energy of laser beam is of order eV as in Pollack effect suggests that Pollack effect or its generalization is the first step in the formation of dark nuclei. This would explain also bio-fusion.

4. Holmlid reports several surprising observations [L6], for instance production of muons and even kaons. The mass of muon is of order 100 MeV and much higher than the nuclear binding energy scale. Kaon mass of kaon is even higher, about 500 MeV. These mass scales are associated with hadron physics, which suggest that somehow hadron physics enters into the picture. The transition changing dark nucleus to ordinary nucleus can liberate so large energy only if the transition to ordinary nucleus occurs quantum coherently for the entire dark nucleus as a collective transition. One could imagine that a dark nucleus formed from deuteron pairs transforms to that formed from ^{4} He nuclei. If one has dark nucleus with mass number Z=32 (Ge) more than 7.8 MeV per nucleon would be liberated in the case of kaon production.

The fact that the energy of the laser beam is of order eV as in Pollack effect suggests that Pollack effect or its analog as a formation of dark nuclei is the first step of CF. This would explain also bio-fusion. Could the already speculated mechanism for bio-fusion work also now?

1. The initial situation would like in Pollack effect. h_{eff} would be large at quantum criticality for the flux tube pair with length scale nm connecting dark nuclei. D-nuclei would be p-n pairs at closed flux loops, length about L_p. In the case of Pollack effect they are flux loops associated with protons, and in the case of D-nuclei they must be accompany nucleons. They cannot be flux tubes connecting p and n to which it is natural to assign keV energy rather than eV energy. This energy can be of order eV also in normal nuclei so that it would correspond to a new nuclear energy scale besides keV. This would mean connection between biology and nuclear physics.

   The loops associated with the nucleons of subsequent D-nuclei reconnect to long flux tube pairs - length of order few nm. h_{eff} is large but Λ correspondingly small so that $T \propto \hbar_{eff}\Lambda$ is small constant and the energy is of order eV. This guarantees the energy degeneration associated with quantum criticality.

2. After than Λ and therefore also T:n increases and the energy for the flux tubes becomes of order MeV. The energy would come from the shift of the nucleon downwards at its Regge trajectory. An analogy of metabolism is in question.

3. At the next step h_{eff} decreases in stepwise manner: $\Delta h_eff/h_0 = \Delta n$. $\Delta n = 1$ is the minimum step, for which the liberated energy would be $\Delta E = e_B$ of order eV. In the general case the liberated energy is $\Delta n e_B$ and is of order keV if Δn is of order $6m_p/m_e \simeq 6 \times 2^{11}$. This is natural if one has $h_{eff}/h_0 = n = 2^{11} \times 6m$. At the step preceding the last one, the distance between D-nuclei would be of order L_e and n would be $n \simeq 6 \times 2^{11}$. After that one would obtain $n = 6$.

One must remember that this is just for-definitess-model and experimental data certainly allow a lot of flexibility.

4.4 What the dark nuclei associated with CF could be?

The idea about dark matter as phases of ordinary matter with $h_{eff} \neq h$ leads to the question whether it is possible to talk about dark nuclei. What could dark nucleus mean?

1. One could think that dark nucleus is generated when the value of h_{eff} at the highest level of hierarchy labelling the thickest flux tube increases and scales like h_{eff}/h. This requires energy. In CF based on electrolysis it would be provided by electric field and in the experiment of Holmlid by laser beam [L6].

2. In electrolysis experiments using ordinary water protons would form the dark nucleus. The corresponding nucleus is not stable and could decay by beta emission. If the value of h_{eff} for weak interactions increases in such a manner that the electroweak scale is larger than the thickness of at dark flux tube and thus of the order of electron length, weak bosons are massless below this scale and weak interactions are as strong as em interaction. Weak decays could take place already at this level. Second option is that also negatively charged flux tubes connecting the protons are allow so that proton can effectively behave like neutron. One can even ask whether the neutrons inside nuclei are actually pairs of protons and negatively charged flux tube.

   Nuclei with different proton and neutron numbers are possible as final states.

3. In electrolysis using heavy water D-nuclei would form dark nuclei as their sequences. Both Pons and Fleichman and Holmlid used heavy water. If the dark nuclei transform directly to ordinary nuclei, the nuclei with identical proton and neutron numbers are favored. These nuclei exists as stable isotopes with largest abundance and they are bosons (D,He,C,N,O,Ne,Mg,Si,S,Ca), which could be of importance from the point of view of quantum biology. Tritium (T) and ^3He cannot be generated n this manner. Also neutrons are impossible. ^{4}He can be generated and was reported already 1920.

   If the photons emitted int he transformation to ordinary nuclei correspond to the energy scale of energy scale of dark nuclei (no change for the bonded nuclei), only X rays would be obtained rather than gama rays. X rays have been reported.

4. ^{11}B, which is stable as also ^{10}B, has one surplus neutron. HB11 is used in the reported CF (`http://tinyurl.com/tbloqfw`). Could protons fuse to dark proton sequence connected by dark flux tubes? Is this enough for cold fusion?

   Or could also ^{11}B nuclei combine to a sequence connected by dark flux tubes with electron radius? Could dark protons fuse in the transition to ordinary nuclei with the surplus neutron and one D of $^{-11}$B to form ^{4}He. This would give stable isotope ^{12}C consisting of ^4H nuclei. The fusion of two D:s to ^He would be a genuine nuclear reaction liberate much higher energy than liberated in the transformation involving only the emission of keV radiation. Already the fusion of two dark D:s to ^4He would produce energy in the same scale as ordinary nuclear fusion.

4.5 A possible model for CF

The energy of laser beam is measured in eVs. Somehow this energy scale must be central for the mechanism involved. This energy scale is same as in Pollack effect, which suggests a connection between these effects. The following scenario is an attempt to formulate what might happen in CF.

1. The generalization of Pollack effect generating flux tube pairs connecting nuclei at distances of order nanometer would initiate the cold fusion process. Flux tube pairs would be generated by reconnection from the flux tube loops associated with nucleons.

   The energy associated e_B associated with the flux tubes would be of order eV and define a new energy scale in nuclear physics. The situation would be quantum critical and involve flux tubes with different lengths $L \propto h_{eff}$ and cosmological constant $\Lambda \propto 1/h_{eff}$ so that the energies e_B would be the same.

2. Quantum criticality would be broken in such a manner that the IR Regge trajectory of nucleon would provide and energy of order nuclear binding energy for the flux tube. Λ would increase by a factor of order 2^{22}. The string tension would produce a force attracting nucleons towards each other and induce a contraction of the dark nucleus, which would correspond to the formation of the ultra-dense phase postulated by Holmlid.

3. The length of dark flux tube connections with length about nanometer scale would shorten about electron Compton length about L_e in a series of phase transitions in which $h_{eff}/h_0 = n$ is reduced as Holmlid's observations suggest. This phase transition series would continue further and eventually lead to ordinary nuclei.

The most general option is that $h_{eff}/h_0 = n$ decreases in stepwise manner. The energy liberated at single step would be $\Delta E = \Delta n e_B$. If one has $\Delta n = 2^{11}$ the liberated energy would be out $\Delta E = 2^{11} e_B$ and in keV range. $h_{eff} = 2^{11} n$ would correspond to this as a reduction of n. This would explain why gamma radiation is not detected and also the reported X rays. The energy scale would be about 1/1000 of the energy scale from that in ordinary nuclear fusion and could partially explain the conflicting views about energy production. The transition series bring nuclei from distance of few nanometers to the distance of nucleon size scale.

4. This suggests that MBs of nuclei play a key role not only in the understanding of nuclei but also of nuclear reactions. A fractal analogy with TGD based view about bio-catalysis emerges. In bio-catalysis the reconnections between the U-shaped long flux tubes associated with reactants allow the reactants to find each other. The energy liberated in the shortening of the flux tube induced by the reduction of h_{eff} would kick the reactants over the potential wall making bio-chemical reactions extremely slow.

   This could happen also in nuclear reactions and explain why the nuclear reactions are possible at temperatures by factor 1/100 lower than the Coulomb wall for point-like nucleons would allow. Coulomb energy at distance of $L(127)$ would be few keV and consistent with the temperature in Sun, which corresponds to thermal energy of about 1.5 keV.

Two kinds of flux tubes would be involved. The flux tubes connecting nucleons of ordinary nuclei with keV energy scale and flux loops assignable to nucleons with eV energy scale.

1. Do also keV flux tubes play some role in CF? Could this be the case in the situation in which nanometer length scale for dark nuclei is not possible (say in hot fusion). Could the IR Regge trajectories provide the energy needed to overcome Coulomb wall in this kind of situations.

2. What can one say about the radii R and lengths L of the flux tubes connecting nuclei of ordinary nucleons? R ei cannot be much larger than the nucleon size but L could be larger. I have considered the possibility that the flux tubes connecting nucleons are loopy just like the "internal" flux tubes associated with nucleons to which one can assign nuclear binding and excitation energies in terms of IR trajectories.

   L could be considerably longer than the M^4 distance between nucleons. This looks strange at first. This which looks strange. The notion of many-sheeted space-time suggests a solution of the problem. The long distance between nucleons along flux tube mediating electric flux would reduce the repulsive Coulomb interaction energy between nucleons.

3. From solar temperature the energy with the flux tube should be of few keV. This suggests that flux tube length corresponds to electron Compton length of order p-adic length scale $L(127)$ by a factor about 2^{11} longer than the distance between nucleons.

4.6 Does the model of CF force to modify the basic views about nuclear physics?

The attitude of the orthodoxy of nuclear physics towards CF has been very repulsive. Perhaps for full reason, CF could be parasite cuckoo evicting the eggs of the host bird from the nest.

1. The notion of Coulomb wall is central in the modelling of nuclear reactions. Its height determines classically what energy is needed to overcome the wall so that the reactions can begin. Nuclear reactions however begin at energies, which are typically about 1/100 of the required energy. Same applies to the needed temperature and thermal distribution of energies does not explain this. This temperature is around million Kelvins in Sun.

2. Quantum mechanical tunnelling is thought to explain this. Also nucleons and nuclei have wave nature and Schrödinger equation allows solutions for which tunnelling through the Coulomb wall is possible. The rate of tunnelling depends very sensitively on height and width of the Coulomb wall via an exponent factor. The height and width of the wall are determined by the details of the potential used to model the strong interaction. By choosing

the potential suitably one can understand the collision energy at which the reactions become possible.

This is however only a model: the parameters of the model are determined separately for each pair of colliding nuclei. A genuine theory would be needed.

What is the situation in TGD?

1. Already the nuclear string model implies a dramatic modification of the existing picture and the introduction of IR Regge trajectories provides the model with additional details and concrete connection with harmonic oscillator model. The nuclear physics is reduced to the level of MBs of nucleons.

2. In zero energy ontology (ZEO) quantum states are superpositions of deterministic classical time evolutions analogous to Bohr orbits connecting 3-surfaces at the boundaries of CD. By holography forced by general coordinate invariance one can speak either about these 3-surfaces or space-time surfaces. Instead of point like particles one has pairs of 3-surfaces having members at opposite boundaries of CD. One indeed has analogs of wave functions as superpositions of these pairs and the analog of tunnelling is possible.

   Tunnelling phenomenon however requires that the 3-surfaces associated with the reacting nuclei at the boundary of CD corresponding to the initial state behave like single particle. This is guaranteed by the flux tube connections between them. This is however not for having quantum-classical correspondence required by ZEO.

3. Quantum criticality is the key element of quantum biology in TGD framework - in fact, entire TGD Universe is quantum critical. The superposition of states involving U-shaped flux tubes of various lengths and values of h_{eff} but of same energy and scanning their environment like tentacles would represent quantum criticality.

   In nuclear reaction one would have quantum critical phase for the bonds connecting nucleons as a superposition of states with different length scale characterized by length scale dependent cosmological constant Λ predicted by the twistor lift of TGD [L11]. The value of the bond energy e_B would be essentially constant. If this applies also to flux tube bonds of nanometer scale appearing in Pollack effect the value of e_B would be of order eV.

4. An interesting question is whether the character of quantum criticality is determined by the environment. A natural upper bound for the variation of h_{eff} and therefore for the length of flux tube length L is determined by the density of nuclei. In solar core the density is about 150 times water density: the flux tubes with nm length scale are not possible and $L_{max} = L_e$ could serve as upper boundary for their scale as assumed in the model for solar core [L21]. In neutron stars L_{max} cannot be much larger than L_p. In Big-Bang nucleosynthesis quantum criticality would have prevailed in the length scale of nucleons.

Quantum classical-correspondence suggests a classical counterpart for the quantum tunnelling. Here one must just imagine different options taking the TGD view about bio-catalysis as a "role model". The following is the simplest toy model achieved hitherto.

1. On basis of quantum biological picture the U-shaped flux tube bonds connecting nucleons of the colliding nuclei having length of about electron Compton length reconnect. This can take place at distance R equal to roughly twice the electron Compton length L_e.

   In Pollack effect the distances L are order nm and because laser light initiates the process, it seems that nm scale is associated with the quantum critical initial situation. The energy e_B of order eV would be same for all flux tubes in the superposition at quantum criticality. Also Holmlid's observations correspond energy e_B in eV range and by criticality $R \sim L_e$ could define upper boundary for the distance L but L in nm scale is not excluded.

   Flux tubes have at quantum criticality also other possible scales and by $h_{eff} = nh_0$ the most general situation corresponds to integer multiples of basic scale such that $h = 6h_0$ corresponds to nucleon scale. $\hbar_{eff}\Lambda = constant$ guarantees energy degeneracy.

In order get to this distance the nuclei must have minimal energy E in cm frame, which is Coulomb potential $V = Z_1 Z_2 e^2/R$ if the situation is 3-D. At this step the strong interaction potentials does not appear at all. For $R = L_e$ E is of the order of keV for $Z_1 = Z_2 = 1$. If the value of h_{eff} for the flux tubes connecting nucleons is about 2^{11} before this, one can understand its length. If the situation is effectively 1-D as it seems, the repulsive Coulomb potential energy of form $V = (Q_1 Q_2 e^2/S)R$, where S is the transversal area of the flux tube: now one would have $Q_1 = Q_2 = 1$.

2. Energy transfer to flux tube with nm scale from nucleon IR Regge trajectory would initiate the reaction: the transferred energy would be few MeV and would induce a dramatic increase of Λ, flux tube tension, and - energy by a factor of order 10^6. The emerging attractive force would compress the flux tube, Coulomb wall would be overcome and the the nuclear reaction could happen via a reduction of h_{eff}.

3. $n = h_{eff}/h_0$ would be reduce in stepwise manner. At step Δn the liberated energy would be $\Delta E = \Delta n e_B$. If the liberate energy corresponds to keV scale, $\Delta n \simeq m_p/m_e \simeq 2^{11}$ is a natural guess. For $h_{eff}/h_0 = n = 2^{11}m$ this guess is natural. Holmlid's observations suggest that $R \sim L_e$ has preferred role. The last reduction $n \simeq 2^{11} \to n = 1$ would lead from the scale L_e to nucleon scale L_p.

   Pollack effect and Holmlid's observations allow to estimate e_B to be of order eV before the initiation of the reaction. e_B would be a new energy scale in nuclear physics and mean a connection with biology.

4. The primary nuclear reactions would occur already in dark phase via the reconnections of quantum critical flux tube bonds. If quantum criticality prevails only during the reaction, a spontaneous reduction of h_{eff} would take place after this and the dark nuclei would transform to ordinary nuclei. For instance, the fusion of two D:s to ^{4}He could occur in the final state.

5. In ZEO BSFR could lead to quantum critical state. After that second BSFR would lead to ordinary nucleons. The space-time surfaces associated with the final state having opposite arrow of time would provide the classical description just as in the case Minev's experiment [L16].

4.7 The anomaly in the nuclear physics of Sun

CF challenges the basic assumptions of nuclear physics but can be labelled as pseudoscience. There is however second anomaly discovered for 10 years ago, and it is not so easy to get rid of this anomaly.

The abundances for nuclei heavier than He in Sun - astrophysicists call these nuclei "metals", which is somewhat misleading term - can be deduced from solar model for the spectrum of solar radiation. The spectral lines at photosphere serve as finger prints. The abundances can be deduced from the intensities of the spectral lines. They can be deduced also from meteorites. These two methods give consistent results.

The third manner to deduce abundances is to use model for the physics of solar core. Here helioseismic waves, which correspond to collective oscillations of Sun, serve as a source of information. Using this information one can build a model for the nuclear abundances in solar interior. Also solar neutrino data can be used. The model can be extrapolated to photosphere. The group led by Martin Asplund observed that the photospheric abundances deduced in this manner are somewhat higher than the abundances deduced from the direct observations [E1] (`http://tinyurl.com/y4bmbjzg`) .

A possible explanation would be that part of the nuclei in the solar core are dark [L21]. Assume that the fraction of ordinary nuclei in the solar core is what standard model of nuclei predicts. One can of course criticize this assumption. If so, the dark fraction of abundances would bring in an additional contribution visible in the description of helioseismic waves in the model and would increase the effective abundances in the core. As one moves to the surface of the Sun, the dark abundances would be reduced and one obtain the abundances deduced from the spectroscopy of the photosphere.

4.8 Some consequences

The possible reshuffling of nuclear physics can have rather dramatic consequences.

1. Standard stellar models cannot explain the presence of nuclei heavier than iron. One proposal is that they are born is supernova explosions in so called r-process based on neutron capture (`http://tinyurl.com/hs3x3se`). Supernova SN1987A did not support this hypothesis.

   Also the abundances of light nuclei Li, Be, B are problematic. Their production in the stellar cores is predicted to be very meager. Their abundances are however high and Li is essential for life. Could CF be responsible for their production outside stellar core. Even ^4He on ongelmallinen ja on myös CNO ongelma [L28] (`http://tinyurl.com/v7chztc` and `http://tinyurl.com/tk9vk6b`).

2. Should one reformulate the ideas about pre-stellar evolution? Could it be that CF has served as "warm-up band", which has liberated nuclear energy, generate nuclei with various masses from hydrogen, and gradually raised the tempature so high, that ordinary nuclear reaction become possible.

3. CF outside stellar cores is possible. What could be the situation in the planetary cores? Usually one thinks that when planet is born, the heavy metals in of proto-planet fall do the core of the planet. Could one think that the metals in the core have born via CF. Could the Fe core of Earth be due to this kind of process? What about the matter in the crust? What about meteorites.

4. Could one think production of heavier elements based on CF? Could it have happened spontaneously and produced ore bodes. What comes in mind is Oklo fissio reactor (`http://tinyurl.com/l3h6t9v`), which is the only known spontaneously formed nuclear reactor at Earth. Could CF have served as "warm-up band" and make possible fission reactions in matter already containing heavy nuclei.

The mechanism of CF and nuclear fusion could be universal and have very general consequences for the understanding of physics in TGD Universe. The notions of magnetic flux tube, hierarchy of effective Planck constants, ZEO based view about state function reduction (SFR), and quantum criticality (QC) of TGD Universe are the essential elements.

1. QC in the initial state would make possible flux tube contacts of small energy between reactants with various lengths as analog of long range fluctuations. This would break the limitation due to the short range of nuclear forces and Coulomb wall and is an essentially new element missing from standard nuclear physics. The values product $h_{eff}\Lambda$ would be constant for the flux tubes in the superposition and $h_{eff} > h$ would be true.

2. At the next step the breaking of QC would be induced by the increase $\Lambda_i \rightarrow_f > \Lambda_i$ of the Λ for flux tubes predicted by twistor lift of TGD [L11] increasing their string tension. The resulting force would attract reactants together and classically would allow to overcome the Coulomb wall so that the reaction could proceed.

   The energy to increase Λ and string tension for the flux tube energy would come from reactants: essentially an analog of metabolic energy would be in question.

   The reduction $h_{eff,i} \rightarrow h_{eff,f} < h_{eff,i}$ would liberate the energy and lead to a shortening of the flux tube allowing to overcome Coulomb wall. After this quantum criticality would prevail again: $(\Lambda_f, h_{eff,f}) \rightarrow (\Lambda_i, h_{eff,i})$.

The mechanism is basically the same as in bio-catalysis [L14], where the energy wall hindering the reactions corresponds to Coulomb wall. The key step is the increase of Λ for long flux tubes. By fractality of TGD Universe this same mechanism could apply also at the level of hadron physics with meson exchange replaced by this mechanism, and also at the level of M_{89} hadron physics defining a scaled up version of ordinary hadron physics emerging at the quantum criticality against what was expected to correspond to color de-confining phase transition. M_{89} hadron physics predicts scaled variants of ordinary mesons for which LHC produced considerable but forgotten evidence as bumps with predicted masses [**?**, K5]. Even application to catastrophic astrophysical events such as creation of supernovae and blackholes and their time reversal meaning birth of stars could involve the same mechanism [L17].

4.9 How TGD could help in the development of CF nuclear technology?

What help could TGD provide in the development of CF-technology. TGD of course provides only a theoretical vision and a lot of theoretical work would be needed to develop it and experimentally test it. TGD could however already in its recent form provide a possible intuition to innovate technical ideas.

1. The production of dark nuclei by phase transition changing ordinary matter dark would be the basic step. Ordinary nuclei would be emerge spontaneously after the reduction of h_{eff}. Both steps would involve BSFR and here a lot of yet non-existing theoretical understanding would be needed. Quantum criticality is second basic idea and also here one must learn a lot. Ordinary criticality accompanies quantum criticality and its role should be understood.

2. CF involves a self-organization process so that energy feed is involved and here several options can be considered. One should find the most effective and most precisely targeted manner to feed energy. In electrolysis the energy is fed via electric field and is perhaps not the best manner to do it. Here also Pollack effect might be involved. Leclair has proposed cavitation as an effective manner to feed energy. The collapse of an acoustically oscillating vapour bubble could liberate energy to build dark nuclei and also lead to sono-fusion [K13].

3. How to harvest the liberated energy most efficiently? The transition to ordinary nuclei should take within reactor volume. If the flux tubes formed are too long, the dark nuclei could leak out of the system and transform to ordinary nuclei outside the system [K13]. The flux tubes assignable to dark nuclei seem to be relatively short but they could be located inside long flux tubes made possible by quantum criticality. LeClair talks about microjets (`http://tinyurl.com/oopu3p2`) and suggests that their birth in cavitation accompanies CF (`http://tinyurl.com/y786gy89`). Leclair has also claimed that fusion products were formed in their experiments at rather large distances from the reaction volume and that the distribution for the isotopes resemble the distribution for r-process in which neutron capture produces nuclei heavier than Fe.

   The dark nuclei in microjets have positive charge and could be attracted by and collide with a negatively charged metal surface. Here one cannot avoid the association with the experiments carried out by Tesla using a voltage critical against dielectric breakdown (quantum criticality). The charged particles were detected in scales considerably larger than the size of the laboratory. Could one test an arrangement, in which positively charged dark nuclei can propagate along flux tube and collide with negatively charged metal targets and transform to ordinary nuclei and liberate their energy?

   One should understand the (topological) dynamics of magnetic flux tubes. In Holmlid's experiments [L6] the length between nucleons along flux tube was of order electron Compton length. The recent view suggests that the radius of flux tubes connecting D nuclei was given by nucleon size scale rather than electron Compton length but what was the typical length of the flux tubes determining the mass number of dark nucleus?

5 The implications of .5 MeV and 3.5 keV monochromatic lines for TGD based nuclear model

Very interesting popular article (`http://tinyurl.com/scuddeg`) in Nature tells about very interesting new results found by Safti et al [E2] (`http://tinyurl.com/um3jreb`). The findings challenge the prevailing particle physics view about existence of galactic dark matter halo and consisting of some exotic new particles behaving like dark matter. These findings add to a long list of negative results related to the existence of dark matter halo and the attempts to find predicted dark matter particles.

There are two observed candidates for particles what would form the speculative galactic dark matter halo. They would have as decay products monochromatic gamma rays at energy of around .5 MeV and 3.5-keV X rays having no standard identification. The recent findings exclude the possibility that these particles reside in the conjectured galactic dark matter halo. They could however reside in galactic centers so that their existence is not challenged.

The detailed consideration of these findings led to an unexpected further progress in TGD based vision about nuclear physics summarized in [L26]. A correct prediction for the energy of 3.5 eV line in terms of cyclotron transition emerges, and also the .5 MeV line is predicted correctly in terms of TGD based nuclear physics [L1, K13, L21] [L26].

It also turns out that TGD inspired nuclear physics provides an explanation for 1 MeV electropion as a scaled down variant of electroweak pseudoscalar P for which evidence as 96 GeV bump exists. Muonic and tau leptopions would correspond to higher families of P. Also other weak bosons as also gluons would have higher families [**?**, K5] as suggested also by the evidence for the breaking of universality of standard model interactions. The p-adically scaled down electroweak bosons would appear as flux tube bonds between nucleons in nuclear string model [L1, L26]. In particular, a pseudoscalar having interpretation as X boson with mass about 17 MeV is also predicted.

CVC and PCAC hypothesis, $M^8 - H$ duality, and p-adic length scale hypothesis support the view that hadron and nuclear physics could allow a description dual to QCD like picture in terms scaled down weak interaction physics. This picture finds concrete quantitative support. Several p-adic length scales would be involved and the active scale would depend on interaction energy.

5.1 .5 MeV gamma ray signal

There is an old gamma ray signal from Milky Way at gamma ray energy of slightly more than electron mass. It has been proposed that it results as dark particle and antiparticle almost at res with respect to each other annihilate. Now it seems that the interpretation as in the proposed sense seems to be excluded.

One can of course, why not a particle which has mass nearly twice the electron mass could not decay to two gamma rays. For some reason this option haven not been experienced as interesting.

1. Support from the existence of pseudo-scalar with this mass emerged already at seventies but because it did not fit witht he standard model picture it was forgotten. Later evidence for a particle with masses twice the mass of muon and tau lepton with similar interpretation emerged. For the same reason also these pieces of evidence were forgotten.

2. TGD led long time ago to what I call lepto-pion hypothesis [K19] (`http://tinyurl.com/vr2ynhp`). In TGD color is not spin-like but angular momentum-like quantum number. Color correspond to the analog of angular momentum for the analog of rigid body rotation in CP_2 degrees freedom. In particular, TGD allows colored excitations of leptons: for instance, electron could appear in color octet state. Color excited electron and positron might form a pion-like color confined pion with mass very nearly 2 times electron mass. Same for muon and tau.

3. These states could be dark in the sense that they have non-standard value of effective Planck constant $h_{eff} = n \times h_0$. This would explain why they are not produced in the decays of Z^0 boson and therefore do not affect its decay rate. Otherwise Z^0 and W decays widths exclude leptopions.

4. This darkness has however nothing to do with the darkness of galactic matter, which reside as energy and possibly dark matter at long very cosmic strings to which linear structures formed by galaxies can be assigned. These cosmic strings can locally thicken to flux tubes and liberate energy as particles forming galaxies. They generate radial gravitational force predicting the flat velocity spectrum of distant stars.

TGD picture would explain why these particles have not been observed outside galactic nucleus. It also turns out that TGD inspired nuclear physics provides an explanation for 1 MeV electropion as a scaled down variant of electroweak pseudoscalar P for which evidence as 96 GeV bump exists. Muonic and tau leptopions would correspond to higher families of P. Also other weak bosons as also gluons would have higher families [**?**, K5] as suggested also by the evidence for the breaking of universality of standard model interactions. The p-adically scaled down electroweak bosons would appear as flux tube bonds between nucleons in nuclear string model [L1, L26].

5.2 3.5-keV X ray signal

Can one imagine any standard physics identification for the 3.5-keV line?. An interesting atomic physics based identification is as X ray emitted in the capture of electron by sulphur ion with principal quantum number $n \geq 9$, which is rather high (`http://tinyurl.com/w9jaqvv`this and `http://tinyurl.com/r6uvwlb`). This requires plasma at temperature of order 3 keV plus cold dense cloud moving at few hundred km/s .

3.5-keV X rays appearing as an un-identified mono-chromatic line in X ray spectrum have been proposed to result from the annihilation of dark particles having mass about 7 keV: annihilation of inert neutrinos is one proposal. The experimental findings exclude the possibility that these X rays are produced in the proposed galactic halo. TGD suggests two alternative explanations based on the notion of monopole flux tube.

1. In TGD framework also 3.5-keV X rays could result in a decay of pion-like state with mass of 7 keV. TGD indeed predicts new nuclear physics in keV scale.

   As a matter fact, TGD leads to a new vision about nuclear physics on basis of model of "cold fusion" [L1, L26, L21] (`http://tinyurl.com/s8gzrfe`) . Magnetic flux carrying monopole flux serve as basic building bricks also now: TGD Universe is indeed fractal.

2. Nuclear string model [L1, K13, L21] relies on the assumption that nuclei are sequences of nucleons connected by pionlike bonds - loopy flux tubes much longer than the M^4 distance between nucleons. These loopy flux tubes have length of order electron Compton length are essential for the TGD based model of nuclear reactions [L26] and also of "cold fusion" [L8].

3. This model allows to consider two options concerning the interpretation of 3.5-keV line.

   Option I: These flux tubes would be like pions with mass about 7 keV decaying to two X rays with energy 3.5-keV. They might be produced even in nuclear physics laboratory. Also now darkness in TGD sense ($h_{eff} = n \times h_0 > h$) is essential and one can talk about dark nuclei.

   In the annihilation of pion like bond to X ray pair, fission of the nucleus would take place. There is no dependence on environmental parameters like temperature.

   Option II:

   The 3.5-keV energy could correspond to a cyclotron transition of for a light quark with mass scale of E=5 MeV assignable to the flux tube having cyclotron energy of this order of magnitude. [Recall that cyclotron frequency is determined by the radius of the monopole flux tube and from the quantization of magnetic flux assumed to be minimal plus the from the fact that $B_{end} = .2$ Gauss for electron is .6 MHz].

   In this case however the pion-like long flux tube bonds between nucleons would have mass about 2 quark masses, which would be of the order of nuclear binding energy of order E rather than being in keV range. The energy differences for subsequent states at nuclear IR Regge trajectories assignable to nucleons are predicted also to have energy of order E. Both the intra-nucleon bonds and inter-nucleon bonds would have the same mass scale. The model for nucleus constructed recently [L26] (`http://tinyurl.com/s8gzrfe`) however assumed that the mass scale for the bond is keV. The masses of ibonds ncreasing mass could be compensated by downwards shifts at IR Regge trajectories of nucleons.

   The cyclotron transitions emitting 3.5-keV X ray would naturally correspond to the return to the ground state after thermal excitation. Temperature would correspond to thermal energy of order 3 keV. The line intensity depends on the temperature of environment.

   Remark: For Option I the cyclotron energies for quarks with masses in keV range would be of order eV, which is also predicted to be a nuclear energy scale in the proposal for TGD based nuclear physics discussed in [L26].

4. The intensity of 3.5-keV lines depends on environment. This excludes Option I but saves Option II. For instance, it is known that 3.5 keV line is associated with galactic clusters and galactic nuclei but not with spheroidal dwarf galaxies with little or no star dust, no recent star formation, and low luminosity (`http://tinyurl.com/wh8lcx4`) . The presence

of plasma at temperature of order 3 keV distinguishing between these options seems necessary. This temperature is possible for several astrophysical X-ray sources (`http://tinyurl.com/te9e7rq`. Also celestial sources such as the surfaces of stars with surface temperature of this order of magnitude are possible (for Sun the surface temperature is 3 orders of magnitude lower).

The temperature of order 3.5 keV makes possible for hot fusion to start- in solar core the temperature is 1.5 keV) so that 3.5 keV line could serve as a signature for regions, where star formation is beginning. In TGD framework, where dark fusion explaining "cold fusion" serves as a "warm-up band" for hot fusion, this correlation is especially natural.

5. One should be able to predict correct value of the cyclotron energy with natural assumptions. The loopy flux tube would correspond to $k = 127$ for electron. The endogenous magnetic field carrying monopole flux corresponds to $B_{end} = .2$ Gauss assignable to $k = 167$ flux tube. The cyclotron of $f_e = B_{end}/m_e$ of is electron $f_J = 6 \times 10^5$ Hz for $h_{eff} = h$. f_e is scaled up by a factor $2^{20} \simeq 10^{12}$ in the replacement $k = 167 \rightarrow 127$.

   Proton cyclotron frequency is scaled $f_p = (m_e/m_p)f_e$. For proton cyclotron energy one obtains $(h_{eff}/h) \times (m_e/m_p) \times (g_p/2) \times f_J$. Proton has magnetic oment $\mu_p = 2.79e/2m_p$. For $h_{eff}/h = 2^{11}$ this gives $E_{c,p}) \simeq 3.78$ keV, which is sligthly higher than 3.5 keV. If one has $h_{eff}/h \simeq m_p/m_e \simeq 1876$ one obtains 3.46 keV quite near to 3.5 keV! For $h_{eff} = h$ one have in this case 1.8 eV so that eV scale emerges and would correspond to the cyclotron energy of single sheet of covering. Therefore proton's cyclotron energy for $h_{eff}/h \simeq m_p/m_e$ or electron's cyclotron frequency for $h_{eff} = h$ could be in question in B_{end} scaled up from $k = 167$ to $k = 127$.

   For neutron the dipole momenta is $\mu_n = -1.91 \times e/2m_p$ and cyclotron energy would be $E_{c,n} = 2.46$ keV, which might be a testable prediction. Cyclotron energy per single sheet would be $E_{c,n} = 1.31$ eV.

5.3 Questions raised by the interpretation of 3.5-keV signal

These interpretation of 3.5-keV signal raises several questions.

1. The earlier proposal has been that nuclear neutrons could correspond to pairs of proton and pion-like flux tube carrying negative charge. The observation above forces to ask whether the intra-nucleon flux tubes carry electrons and have $h_{eff} = h$. Could nuclear proton transform effectively to neutron by the presence of flux tube carrying electron so that the idea about neutrons as pairs of proton and electron-neutrino pair could make sense inside nuclei.

2. Could also interpret the bonds as scaled down analogs of weak bosons? I have actually considered the possibility of scaled down variants of electroweak gauge bosons earlier in the model [L7] for the so called X boson anomaly [L7, C2]. The inspiration for this came from CVC *resp.* PCAC hypothesis relates the conserved vectorial *resp.* partially conserved axial electroweak currents to strong interactions. This hypothesis is encouraged also by $M^8 - H$ duality strongly suggesting that QCD type description provides the quark-gluon description at high energies at the level of $H = M^4 \times CP_2$ and $M^8 = M^4 \times E^4$ description provides the description of hadron physics in terms of $O(4) = SU(2) \times SO(3)$ symmetry group acting as isometries of E^4 of old-fashioned hadron physics appearing in CVC and PCAC.

   What is important is that weak bosons would be effectively massless below the scaled up weak scale $L(127)$, and depending on the situation also to some other scales as p-adic length scale hypothesis suggests, and being as strong as electromagnetic interactions below this scale. Could one interpret strong interactions in hadronic and nuclear scales as scaled-down weak interactions?

This hypothesis combined with p-adic length scale hypothesis is very powerful and can be tested.

1. Higgs boson with mass 125 GeV would correspond to $k = 89$. Higgs mass would be minimal possible if p-adic mass squared is of order $O(p)$ so that real mass squared is $m_R^2 = 1/p$.

Contrary to the long-held expectations W and Z bosons with standard values of Weinberg angle naturally correspond to $k = 90$ if pure U(1) boson would have Higgs mass.

TGD predicts also pseudo-scalar variant of Higgs. For $k = 90$ the minimal mass would be 88 GeV. LHC has observed a bump at about 96 GeV (`http://tinyurl.com/yyqwlh44`), and this could correspond to pseudo-scalar Higgs, call it P, and assume its mass is indeed 96 GeV. The masses of weak bosons would be therefore $(m(H), m(P), m(W), m(Z)) = (125, 96, 80.4, 91.2)$ GeV and masses for other p-adic length scales follow by simple scaling.

2. The masses of Higgs and W and Z bosons with same Weinberg angle for $k = 127$ would be obtained by scaling with a factor $2^{(-127+k)/2}$, $k = 89$ for Higgs and $k = 90$ for P, W and Z. This would give $(m(H), m(P), m(W), m(Z)) = (.238, .129, .11, .12)$ MeV. What is nice is that these scales are considerably below the nuclear binding energy scale about 7-8 MeV per nucleon for heavier and 1.1 MeV for D so that one could indeed assign nuclear binding and excitation energies to the nucleon flux tubes as proposed in [L26].

This raises questions.

1. Could also the intra-nuclear flux tube bonds have scaled-down weak boson masses but with different p-adic length scale? Can one regard the electrons in these bonds effectively as free electrons as far as cyclotron energies are considered? Could the old-fashioned hadron physics at least partially reduce to weak interaction physics below electron Compton length and possible other p-adic length scales assignable to the flux tubes involved?

2. Intra-nucleon flux tubes have been assumed to have intra-nucleon binding energy scale about 7-8 MeV (1.1 MeV for neutron-proton pair)? The proposal is that binding energy scale corresponds to the energy scale of IR Regge trajectories for nucleons and is thus single nucleon property (or that of the MB of nucleon). Nuclear strings would be strings formed from ^{4}He strings a units, possible D type string, and lonely nucleons (protons or neutrons depending on the sign of $Z - N$.

   Nuclear binding energy scale 7-8 MeV would be assignable to the MB of nucleons of ^{4}He and of heavier nuclei and 1 MeV energy scale to the MBs of p and n in D. The binding energy scale and energy scale of excitations would be determined by the p-adic length scale assignable to the intra-nucleon flux tubes and depending on environment via the value of k defining the p-adic lengths scale.

3. What would this mean p-adically? The scaling of weak boson masses with mass scale .1 MeV to larger mass scale should correspond to that for the binding energy scale and give binding energy scale 1 MeV for D and 8 MeV for ^{4}He.

   (a) Consider first 1 MeV scale assignable to intra-nucleon flux tubes in D. $k = 127-6 = 121$ would give $(m_H, m_P, m_W, m_Z) = (1.90, 1.06, .877, .8)$ MeV. The mass of P is quite near the the D binding energy 1.11 MeV.

   A connection with lepto-hadron hypothesis [K19] (`http://tinyurl.com/vr2ynhp`) suggests itself. For $k = 121 = 11^2$ the mass of P would be 1.06 MeV and very nearly twice the electron mass 1.022 MeV. The mass of the electr-pion proposed to explain the pseudo-scalar resonance observed in heavy ion collisions is very very near to $2m_e$. Could electro-pion identified as a pair of color octet leptons correspond scaled down P? Also evidence for muon-pion and tau-pion exists. Could these correspond to higher generations of weak bosons predicted by TGD?

   Recall that there were to alternative interpretations for 3.5-keV line as cyclotron energy of proton with $h_{eff}/h \simeq m_p/m_e$ or of electron with $h_{eff}/h = 1$. The interpretation of the flux tube as electro-pion/P selects the latter interpretation. This modifies the model of "cold fusion" [L26] based on quantum criticality and the model of bio-catalysis, and also explains why the flux tubes with radius about electron Compton length are of special importance as the work of Holmlid shows [L6] [L6]. One would have $h_{eff}/h \simeq 2^{11}$ for the quantum critical flux tubes with nanometer length scale central also for TGD inspired quantum biology and giving rise to dark variant of DNA as dark nuclei consisting of dark proton sequences [L29]. This would also explain biofusion [C1, C10] as a special case

of "cold fusion". Note that the magnetic field strength would be smaller by factor 2^{-11} by the reduction of the length scale dependent cosmological constant Λ and cyclotron energy would be same. A deep connection between biology and nuclear physics would emerge.

(b) What about 7-8 MeV scale? $k = 113$ is basic candidate for nuclear scale and the corresponding masses would be scaled by factor $2^7 = 128$ giving $(m_H, m_P, m_W, m_Z) = (30.5, 16.5, 14.1, 15.4)$ MeV. These scales are too large by a factor of order 2 that $k = 111$ looks more appropriate.

4. There exists evidence for so called X boson with mass of 17 MeV [L7, C2]. One interpretation would be in terms of pion like state which could corresponds to the electroweak pseudo-scalar predicted by TGD. The mass of $k = 113$ P-boson would be 16.5 MeV and quite near to X boson mass. This would suggest that several p-adic length scales are indeed possible. This interpretation can be tested by checking whether other exotic bosons in this range exist.

To sum up, the TGD inspired model for nucleus predicts correctly the 3.5-eV X ray energy as cyclotron energy with using the earlier assumptions of the model. Also other predictions and tests follow. For instance, the model could be tested by irradiating nuclei in laboratory using 3.5 eV X rays and looking whether this has effects. For instance, nuclear decay rates could be affected.

What $M^8 - H$ duality together with CVC and PCAC suggests and the above observations quantitatively support is that p-adic length scale hierarchy could allow a description of hadronic and nuclear physics in terms of p-adically scaled down variants of weak interactions such that the value of k for weak bosons would depend on the energy scale of the strong interactions.

REFERENCES

Mathematics

[A1] N. Hitchin. Kählerian twistor spaces. *Proc London Math Soc.* Available at: `http://tinyurl.com/pb8zpqo`, 8(43):133–151, 1981.

Theoretical Physics

[B1] Minev ZK et al. To catch and reverse a quantum jump mid-flight. arXiv:1803.00545 [quant-ph]. Available at: `https://arxiv.org/abs/1803.00545`, 2019.

Particle and Nuclear Physics

[C1] Kervran CL. *Biological transmutations, and their applications in chemistry, physics, biology, ecology, medicine, nutrition, agriculture, geology.* Swan House Publishing Co., 1972.

[C2] Feng JL et al. Evidence for a protophobic fifth force from ^{8}be nuclear transitions. Available at: `http://arxiv.org/abs/1604.07411`, 2015.

[C3] Jenkins JH et al. Evidence for Correlations Between Nuclear Decay Rates and Earth-Sun Distance. Available at: `http://arxiv.org/abs/0808.3283`, 2008.

[C4] Krasznahorkay A et al. Observation of anomalous internal pair creation in 8be: A possible indication of a light, neutral boson. Available at: `https://arxiv.org/abs/1504.0152`, 2016.

[C5] Mizuno T et al. Hydrogen Evolution by Plasma Electrolysis in Aqueous solution. *Jap J Appl Phys*, 44(1):396–401, 2002.

[C6] Holmlid L and Kotzias B. Phase transition temperatures of 405-725 K in superfluid ultra-dense hydrogen clusters on metal surfaces. *AIP Advances.* Available at: `http://tinyurl.com/hxbvfc7`, 6(4), 2016.

[C7] Krivit SB. *Fusion Fiasco: Explorations in Nuclear Research, vol II.* Pasific Oaks Press. San Rafael, California. http://stevenbkrivit.com/fusion-fiasco/, 2017.

[C8] Krivit SB. *Hacking the atom: Explorations in Nuclear Research, vol I.* Pasific Oaks Press. San Rafael, California. http://stevenbkrivit.com, 2017.

[C9] Krivit SB. *Lost History: Explorations in Nuclear Research, vol III.* Pasific Oaks Press. San Rafael, California. http://stevenbkrivit.com/lost-history/, 2017.

[C10] Bird C Tompkins P. *The secret life of plants.* Harper & Row, New York, 1973.

Cosmology and Astro-Physics

[E1] Sauval J Scott P Asplund M, Grevesse N. The Chemical Composition of the Sun. *Annual Review of Astronomy and Astrophysics.*Available at*: https://doi.org/10.1146/annurev.astro.46.060407.145222*, 47:481–522, 2009.

[E2] Safti R Dessert C, Rodd NL. The dark matter interpretation of the 3.5-keV line is inconsistent with blank-sky observations. *Science.* Available at*: https://science.sciencemag.org/content/367/6485/1465*, 367(6485):1465–1467, 2020.

[E3] Ferguson JF Asplund M Serenelli AM, Basu S. New Solar Composition: The Problem With Solar Models Revisited. arXiv:0909.2668 [astro-ph]. Available at:https://arxiv.org/pdf/0909.2668.pdf, 2009.

Biology

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

Neuroscience and Consciousness

[J1] Libet B. Readiness potentials preceding unrestricted spontaneous and preplanned voluntary acts. Available at: http://tinyurl.com/jqp1, 1982.

Books related to TGD

[K1] Pitkänen M. Construction of elementary particle vacuum functionals. In *p-Adic Physics.* Available at: http://tgdtheory.fi/pdfpool/elvafu.pdf, 2006.

[K2] Pitkänen M. Magnetic Sensory Canvas Hypothesis. In *TGD and EEG.* Available at: http://tgdtheory.fi/pdfpool/mec.pdf, 2006.

[K3] Pitkänen M. Massless states and particle massivation. In *p-Adic Physics.* Available at: http://tgdtheory.fi/pdfpool/mless.pdf, 2006.

[K4] Pitkänen M. New Particle Physics Predicted by TGD: Part I. In *p-Adic Physics.* Available at: http://tgdtheory.fi/pdfpool/mass4.pdf, 2006.

[K5] Pitkänen M. New Particle Physics Predicted by TGD: Part II. In *p-Adic Physics.* Available at: http://tgdtheory.fi/pdfpool/mass5.pdf, 2006.

[K6] Pitkänen M. Quantum Antenna Hypothesis. In *Quantum Hardware of Living Matter.* Available at: http://tgdtheory.fi/pdfpool/tubuc.pdf, 2006.

[K7] Pitkänen M. Quantum Model for Bio-Superconductivity: I. In *TGD and EEG.* Available at: http://tgdtheory.fi/pdfpool/biosupercondI.pdf, 2006.

[K8] Pitkänen M. Quantum Model for Bio-Superconductivity: II. In *TGD and EEG*. Available at: http://tgdtheory.fi/pdfpool/biosupercondII.pdf, 2006.

[K9] Pitkänen M. Construction of Quantum Theory: More about Matrices. In *Towards M-Matrix: part I*. Available at: http://tgdtheory.fi/pdfpool/UandM.pdf, 2012.

[K10] Pitkänen M. *p-Adic length Scale Hypothesis*. Online book. Available at: http://www.tgdtheory.fi/tgdhtml/padphys.html, 2013.

[K11] Pitkänen M. Why TGD and What TGD is? In *Topological Geometrodynamics: an Overview*. Available at: http://tgdtheory.fi/pdfpool/WhyTGD.pdf, 2013.

[K12] Pitkänen M. About Preferred Extremals of Kähler Action. In *Physics in Many-Sheeted Space-Time: Part I*. Available at: http://tgdtheory.fi/pdfpool/prext.pdf, 2019.

[K13] Pitkänen M. Cold Fusion Again. In *Hyper-finite Factors and Dark Matter Hierarchy: Part II*. Available at: http://tgdtheory.fi/pdfpool/coldfusionagain.pdf, 2019.

[K14] Pitkänen M. Criticality and dark matter. In *Hyper-finite Factors and Dark Matter Hierarchy: Part I*. Available at: http://tgdtheory.fi/pdfpool/qcritdark.pdf, 2019.

[K15] Pitkänen M. Nuclear String Hypothesis. In *Hyper-finite Factors and Dark Matter Hierarchy: Part II*. Available at: http://tgdtheory.fi/pdfpool/nuclstring.pdf, 2019.

[K16] Pitkänen M. Solar Metallicity Problem from TGD Perspective. Available at: http://tgdtheory.fi/pdfpool/darkcore.pdf, 2019.

[K17] Pitkänen M. Some questions related to the twistor lift of TGD. In *Towards M-Matrix: Part II*. Available at: http://tgdtheory.fi/pdfpool/twistquestions.pdf, 2019.

[K18] Pitkänen M. TGD and Nuclear Physics. In *Hyper-finite Factors and Dark Matter Hierarchy: Part II*. Available at: http://tgdtheory.fi/pdfpool/padnucl.pdf, 2019.

[K19] Pitkänen M. The Recent Status of Lepto-hadron Hypothesis. In *Hyper-finite Factors and Dark Matter Hierarchy: Part II*. Available at: http://tgdtheory.fi/pdfpool/leptc.pdf, 2019.

[K20] Pitkänen M. Could TGD provide new solutions to the energy problem? In *Hyper-finite Factors and Dark Matter Hierarchy: Part II*. Available at: http://tgdtheory.fi/pdfpool/proposal.pdf, 2020.

Articles about TGD

[L1] Pitkänen M. Further Progress in Nuclear String Hypothesis. Available at: http://tgdtheory.fi/public_html/articles/nuclstring.pdf, 2007.

[L2] Pitkänen M. Pollack's Findings about Fourth phase of Water : TGD View. Available at: http://tgdtheory.fi/public_html/articles/PollackYoutube.pdf, 2014.

[L3] Pitkänen M. Cold Fusion Again . Available at: http://tgdtheory.fi/public_html/articles/cfagain.pdf, 2015.

[L4] Pitkänen M. About minimal surface extremals of Kähler action. Available at: http://tgdtheory.fi/public_html/articles/minimalkahler.pdf, 2016.

[L5] Pitkänen M. Hydrinos again. Available at: http://tgdtheory.fi/public_html/articles/Millsagain.pdf, 2016.

[L6] Pitkänen M. Strong support for TGD based model of cold fusion from the recent article of Holmlid and Kotzias. Available at: http://tgdtheory.fi/public_html/articles/holmilidnew.pdf, 2016.

[L7] Pitkänen M. X boson as evidence for nuclear string model. Available at: http://tgdtheory.fi/public_html/articles/Xboson.pdf, 2016.

[L8] Pitkänen M. Cold fusion, low energy nuclear reactions, or dark nuclear synthesis? Available at: http://tgdtheory.fi/public_html/articles/krivit.pdf, 2017.

[L9] Pitkänen M. Philosophy of Adelic Physics. Available at: http://tgdtheory.fi/public_html/articles/adelephysics.pdf, 2017.

[L10] Pitkänen M. Philosophy of Adelic Physics. In *Trends and Mathematical Methods in Interdisciplinary Mathematical Sciences*, pages 241–319. Springer.Available at: https://link.springer.com/chapter/10.1007/978-3-319-55612-3_11, 2017.

[L11] Pitkänen M. Questions about twistor lift of TGD. Available at: http://tgdtheory.fi/public_html/articles/twistquestions.pdf, 2017.

[L12] Pitkänen M. Re-examination of the basic notions of TGD inspired theory of consciousness. Available at: http://tgdtheory.fi/public_html/articles/conscrit.pdf, 2017.

[L13] Pitkänen M. Dark valence electrons and color vision. Available at: http://tgdtheory.fi/public_html/articles/colorvision.pdf, 2018.

[L14] Pitkänen M. Getting philosophical: some comments about the problems of physics, neuroscience, and biology. Available at: http://tgdtheory.fi/public_html/articles/philosophic.pdf, 2018.

[L15] Pitkänen M. TGD view about coupling constant evolution. Available at: http://tgdtheory.fi/public_html/articles/ccevolution.pdf, 2018.

[L16] Pitkänen M. Copenhagen interpretation dead: long live ZEO based quantum measurement theory! Available at: http://tgdtheory.fi/public_html/articles/Bohrdead.pdf, 2019.

[L17] Pitkänen M. Cosmic string model for the formation of galaxies and stars. Available at: http://tgdtheory.fi/public_html/articles/galaxystars.pdf, 2019.

[L18] Pitkänen M. Does coupling constant evolution reduce to that of cosmological constant? Available at: http://tgdtheory.fi/public_html/articles/ccevoTGD.pdf, 2019.

[L19] Pitkänen M. $M^8 - H$ duality and consciousness. Available at: http://tgdtheory.fi/public_html/articles/M8Hconsc.pdf, 2019.

[L20] Pitkänen M. Minimal surfaces: comparison of the perspectives of mathematician and physicist. Available at: http://tgdtheory.fi/public_html/articles/minimalsurfaces.pdf, 2019.

[L21] Pitkänen M. Solar Metallicity Problem from TGD Perspective. Available at: http://tgdtheory.fi/public_html/articles/darkcore.pdf, 2019.

[L22] Pitkänen M. Some comments related to Zero Energy Ontology (ZEO). Available at: http://tgdtheory.fi/public_html/articles/zeoquestions.pdf, 2019.

[L23] Pitkänen M. SUSY in TGD Universe. Available at: http://tgdtheory.fi/public_html/articles/susyTGD.pdf, 2019.

[L24] Pitkänen M. TGD inspired theory of consciousness and living systems. Available at: http://tgdtheory.fi/public_html/articles/badenbaden.pdf, 2019.

[L25] Pitkänen M. Trying to understand why ramified primes are so special physically. Available at: http://tgdtheory.fi/public_html/articles/ramified.pdf, 2019.

[L26] Pitkänen M. Could TGD provide new solutions to the energy problem? Available at: http://tgdtheory.fi/public_html/articles/proposal.pdf, 2020.

[L27] Pitkänen M. Exotic pion like states as "infra-red" Regge Trajectories and a new view about nuclear physics. Available at: `http://tgdtheory.fi/public_html/articles/pionlikestate.pdf`, 2020.

[L28] Pitkänen M. Helium problem and CNO problem: two anomalies explained by dark fusion. Available at: `http://tgdtheory.fi/public_html/articles/hecnoproblem.pdf`, 2020.

[L29] Pitkänen M. New results about dark DNA inspired by the model for remote DNA replication. Available at: `http://tgdtheory.fi/public_html/articles/darkdnanew.pdf`, 2020.

[L30] Pitkänen M. The dynamics of SSFRs as quantum measurement cascades in the group algebra of Galois group. Available at: `http://tgdtheory.fi/public_html/articles/SSFRGalois.pdf`, 2020.