Dark Nuclear Physics and Condensed Matter

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Abstract

In this chapter the possible effects of dark matter in nuclear physics and condensed matter physics are considered. The spirit of the discussion is necessarily rather speculative. The most general form of the hierarchy would involve both singular coverings and factors spaces of CD (causal diamond of M^4) defined as intersection of future and past directed light-cones) and CP_2. There are grave objections against the allowance of factor spaces. In this case Planck constant could be smaller than its standard value and there are very few experimental indications for this. Quite recently came the realization that the hierarchy of Planck constants might emerge from the basic quantum TGD as a consequence of the extreme non-linearity of field equations implying that the correspondence between the derivatives of imbedding space coordinates and canonical momentum is many-to-one. This makes natural to the introduction of covering spaces of CD and CP_2.

Planck constant would be effectively replaced with a multiple of ordinary Planck constant defined by the number of the sheets of the covering. The space-like 3-surfaces at the ends of the causal diamond and light-like 3-surfaces defined by wormhole throats carrying elementary particle quantum numbers would be quantum critical in the sense of being unstable against decay to many-sheeted structures. Charge fractionization could be understood in this scenario. Biological evolution would have the increase of the Planck constant as as one aspect. The crucial scaling of the size of CD by Planck constant can be justified by a simple argument. Note that primary p-adic length scales would scale as $\sqrt{\hbar}$ rather than $\hbar$ as assumed in the original model.

Recently the hierarchy of Planck constants have been traced to the non-determinism of Kähler action predicting in zero energy ontology (ZEO) that two space-like 3-surfaces at the ends of causal diamonds (CD) can be connected by several space-time surfaces. As a matter fact, by infinite number of them related by quantum critical deformations identifiable as conformal transformations respecting the light-likeness of partonic orbits at which the signature of the induced metric changes. The number of conformal equivalence classes of space-time sheets would be integer n defining the effective Planck constant $h_{eff} = n \times h$.

1. What darkness means?

Dark matter is identified as matter with non-standard value of Planck constant. The weak form of darkness states that only some field bodies of the particle consisting of flux quanta mediating bound state interactions between particles become dark. One can assign to each interaction a field body (em, Z^0, W, gluonic, gravitational) and p-adic prime and the value of Planck constant characterize the size of the particular field body. One might even think that particle mass can be assigned with its em field body and that Compton length of particle corresponds to the size scale of em field body.

Nuclear string model suggests that the sizes of color flux tubes and weak flux quanta associated with nuclei can become dark in this sense and have size of order atomic radius so that dark nuclear physics would have a direct relevance for condensed matter physics. If this happens, it becomes impossible to make a reductionistic separation between nuclear physics and condensed matter physics and chemistry anymore.

2. What dark nucleons are?

The basic hypothesis is that nuclei can make a phase transition to dark phase in which the size of both quarks and nuclei is measured in Angstroms. For the less radical option this transition could happen only for the color, weak, and em field bodies. Proton connected by dark color bonds super-nuclei with inter-nucleon distance of order atomic radius might be crucial for understanding the properties of water and perhaps even the properties of ordinary condensed matter. Large $\hbar$ phase for weak field body of D and Pd nuclei with size scale of atom would explain selection rules of cold fusion.

3. Anomalous properties of water and dark nuclear physics

A direct support for partial darkness of water comes from the $H_{1.5}O$ chemical formula supported by neutron and electron diffraction in attosecond time scale. The explanation could be that one fourth of protons combine to form super-nuclei with protons connected by color bonds and having distance sufficiently larger than atomic radius.

The crucial property of water is the presence of molecular clusters. Tedrahedral clusters allow an interpretation in terms of magic Z=8 protonic dark nuclei. The icosahedral clusters consisting of 20 tedrahedral clusters in turn have interpretation as magic dark dark nuclei: the presence of the dark dark matter explains large portion of the anomalies associated with water

and explains the unique role of water in biology. In living matter also higher levels of dark matter hierarchy are predicted to be present. The observed nuclear transmutation suggest that also light weak bosons are present.

4. Implications of the partial darkness of condensed matter

The model for partially dark condensed matter inspired by nuclear string model and the model of cold fusion inspired by it allows to understand the low compressibility of the condensed matter as being due to the repulsive weak force between exotic quarks, explains large parity breaking effects in living matter, and suggests a profound modification of the notion of chemical bond having most important implications for bio-chemistry and understanding of bio-chemical evolution.

1 Introduction

The unavoidable presence of classical long ranged weak (and also color) gauge fields in TGD Universe has been a continual source of worries for more than two decades. The basic question has been whether electro-weak charges of elementary particles are screened in electro-weak length scale or not. The TGD based view about dark matter assumes that weak charges are indeed screened for ordinary matter in electro-weak length scale but that dark electro-weak bosons correspond to much longer symmetry breaking length scale.

The large value of $\hbar$ in dark matter phase implies that Compton lengths and -times are scaled up. In particular, the sizes of nucleons and nuclei become of order atom size so that dark nuclear physics would have direct relevance for condensed matter physics. It becomes impossible to make a reductionistic separation between nuclear physics and condensed matter physics and chemistry anymore.

In its original form this chapter was an attempt to concretize and develop ideas related to dark matter by using some experimental inputs with emphasis on the predicted interaction between the new nuclear physics and condensed matter. As the vision about dark matter became more coherent and the nuclear string model developed in its recent form, it became necessary to update the chapter and throw away the obsolete material. I have also divided the material to two chapters such that second chapter focuses to dark weak and color forces and their implications. I dare hope that the recent representation is more focused than the earlier one.

1.1 Dark Rules

I have done a considerable amount of trials and errors in order to identify the basic rules allowing to understand what it means to be dark matter is and what happens in the phase transition to dark matter. It is good to try to summarize the basic rules of p-adic and dark physics allowing to avoid obvious contradictions.

1.1.1 Could basic quantum TGD imply the hierarchy of Planck constants?

The implications of the hierarchy of Planck constants depend on whether one assumes it as an independent additional postulate or as a consequence of basic quantum TGD. The first option originally motivated by physical anomalies would allow both singular coverings and factor spaces. The latter option, which emerged five years after the basic idea, would allow only singular coverings. They would provide only a convenient tool to describe the fact that the correspondence between canonical momentum densities and time derivatives of the imbedding space coordinates at the ends of space-time sheets is not one-to-one. As a matter fact, this observation forced the idea about quantum physics as classical physics in the "world of classical worlds" for two decades ago. The quantization of Planck constant as integer multiples of its standard value would be an effective phenomenon for this option holding true at the sheets of the covering. These options lead to different predictions and one can in principle test whether either of them is correct.

1.1.2 The notion of field body

The notion of "field body" implied by topological field quantization is essential piece of classical TGD. It seems possible to assign to physical systems field identities- that is separate magnetic and

electric field bodies identifiable as flux quanta. This is not possible in Maxwell's electrodynamics. The first naive guess was that one can speak of separate em, Z^0, W, gluonic, and gravitonic field bodies, each characterized by its own p-adic prime. The tight constraints coming from the fact that the induced gauge fields are expressible in terms of CP_2 coordinates and their derivatives implies however strong correlations between classical gauge fields. For instance, the vanishing of classical Kähler field for vacuum extremals implies that em and Z^0 fields are proportional to each other. The non-vanishing of induced Kähler field in turn implies non-vanishing classical color fields. This gives rise at least to two basic types of field bodies predicting a lot of new physics even in macroscopic length scales. For instance, electric and magnetic flux tubes must have at their ends quarks and antiquarks serving as sources of classical color fields unless one believes that vacuum charge densities serve as sources of these fields. In the similar manner neutrinos and antineutrinos are needed to create classical Z^0 fields associated with almost vacuum extremal flux tubes. These fields could be interpreted also as vacuum polarization effects and one could distinguish them from fields created by genuine sources. For instance, the unavoidable classical color fields associated with the flux tubes of electromagnetic field body which is not vacuum extremal would represent vacuum polarization in macroscopic scale.

What is interesting that the conceptual separation of interactions to various types would have a direct correlate at the level of space-time topology. From a different perspective inspired by the general vision that many-sheeted space-time provides symbolic representations of quantum physics, the very fact that we make this conceptual separation of fundamental interactions could reflect the topological separation at space-time level.

The p-adic mass calculations for quarks encourage to think that the p-adic length scale characterizing the mass of particle is associated with its electromagnetic body and in the case of neutrinos with its Z^0 body. Z^0 body can contribute also to the mass of charged particles but the contribution would be small. It is also possible that these field bodies are purely magnetic for color and weak interactions. Color flux tubes would have exotic fermion and anti-fermion at their ends and define colored variants of pions. This would apply not only in the case of nuclear strings but also to molecules and larger structures so that scaled variants of elementary particles and standard model would appear in all length scales as indeed implied by the fact that classical electro-weak and color fields are unavoidable in TGD framework.

One can also go further and distinguish between magnetic field body of free particle for which flux quanta start and return to the particle and "relative field" bodies associated with pairs of particles. Very complex structures emerge and should be essential for the understanding the space-time correlates of various interactions. In a well-defined sense they would define space-time correlate for the conceptual analysis of the interactions into separate parts. In order to minimize confusion it should be emphasized that the notion of field body used in this chapter relates to those space-time correlates of interactions, which are more or less *static* and related to the formation of *bound states*.

1.1.3 What dark variant of elementary particle means

It is not at all clear what the notion of dark variant of elementary particle or of larger structures could mean.

1. Are only field bodies dark?

One variety of dark particle is obtained by making some of the field bodies dark by increasing the value of Planck constant. This hypothesis could be replaced with the stronger assumption that elementary particles are maximally quantum critical systems so that they are same irrespective of the value of the Planck constant. Elementary particles would be represented by partonic 2-surfaces, which belong to the universal orbifold singularities remaining invariant by all groups $G_a \times G_b$ for a given choice of quantization axes. If $G_a \times G_b$ is assumed to leave invariant the choice of the quantization axes, it must be of the form $Z_{n_a} \times Z_{n_b} \subset SO(3) \times SU(3)$. Partonic 2-surface would belong to $M^2 \times CP_2/U(1) \times U(1)$, where M^2 is spanned by the quantization axis of angular momentum and the time axis defining the rest system.

A different manner to say this is that the CP_2 type extremal representing particle would suffer multiple topological condensation on its field bodies so that there would be no separate "particle space-time sheet".

Darkness would be restricted to particle interactions. The value of the Planck constant would be assigned to a particular interaction between systems rather than system itself. This conforms with the original finding that gravitational Planck constant satisfies $\hbar = GM_1M_2/v_0$, $v_0 \simeq 2^{-11}$. Since each interaction can give rise to a hierarchy dark phases, a rich variety of partially dark phases is predicted. The standard assumption that dark matter is visible only via gravitational interactions would mean that gravitational field body would not be dark for this particular dark matter.

Complex combinations of dark field bodies become possible and the dream is that one could understand various phases of matter in terms of these combinations. All phase transitions, including the familiar liquid-gas and solid-liquid phase transitions, could have a unified description in terms of dark phase transition for an appropriate field body. At mathematical level Jones inclusions would provide this description.

The book metaphor for the interactions at space-time level is very useful in this framework. Elementary particles correspond to ordinary value of Planck constant analogous to the ordinary sheets of a book and the field bodies mediating their interactions are the same space-time sheet or at dark sheets of the book.

2. Can also elementary particles be dark?

Also dark elementary particles themselves rather than only the flux quanta could correspond to dark space-time sheet defining multiple coverings of $H/G_a \times G_b$. This would mean giving up the maximal quantum criticality hypothesis in the case of elementary particles. These sheets would be exact copies of each other. If single sheet of the covering contains topologically condensed space-time sheet, also other sheets contain its exact copy.

The question is whether these copies of space-time sheet defining classical identical systems can carry different fermionic quantum numbers or only identical fermionic quantum numbers so that the dark particle would be exotic many-fermion system allowing an apparent violation of statistics (N fermions in the same state).

Even if one allows varying number of fermions in the same state with respect to a basic copy of sheet, one ends up with the notion of N-atom in which nuclei would be ordinary but electrons would reside at the sheets of the covering. The question is whether symbolic representations essential for understanding of living matter could emerge already at molecular level via the formation of N-atoms.

1.1.4 What happens in charge fractionization?

The hierarchy of Planck constants suggests strongly charge fractionization. What happens for binding energies is however not obvious. The first guess is that one just replaces $\hbar$ with its scaled value in the standard formulas. One can however ask whether the resulting expression applies to single sheet of covering or to the sum of binding energies associated with the sheets of covering. In the case of factor space analogous problem is not encountered.

If the coverings follow from basic quantum TGD one can deduce unique rules for what happens. These rules can be assumed also in the more general case. Since the sheets of the singular covering co-incide at the partonic 2-surfaces associated with ends of CD the time evolution and also "evolution" in space-like direction means instability of in the sense that partonic 2-surface decomposes to $r = \hbar/\hbar_0 = n_an_b$ sheets. This implies fractionization of all total quantum numbers such as energy and momentum. From this one can also deduce what happens to various binding energies. For instance, the total (!) cyclotron energy is indeed multiplied by factor and the total(!) binding energy of dark hydrogen atom is what the naive scaling of $\hbar$ would give. The reason is that the mass of particle is fractionized: $m \to m/n_an_b$. Therefore the original guesses would be correct. In particular, the expression of the total gravitational binding energy essential for the original Bohr model of planetary orbits is consistent with the new more precise rules.

1.1.5 Criterion for the transition to dark phase

The naive criterion $\alpha Q_1Q_2 > 1$ (or its generalization) for the transition to dark matter phase relates always to the interaction between two systems and the interpretation is that when the field strength characterizing the interaction becomes too strong, the interaction is mediated by dark

space-time sheets which define $n = n(G_a) \times n(G_b)$-fold covering of $M^4 \times CP_2/G_a \times G_b$. The sharing of flux between different space-time sheets reduces the field strength associated with single sheet below the critical value.

For the option in which singular coverings follow from basic quantum TGD this criterion or its appropriate generalization has very concrete interpretation. At the ends of CD the partonic 2-surface is unstable against decay to n_a sheets when some of the quantum numbers of the partonic 2-surface are too large. A similar decay to n_b sheets would happen also when one moves in space-like direction.

One can ask whether this instability could have something to do with N-vertices of generalized Feynman diagrams in which decay of a partonic 2-surfaces to N-1 surfaces takes place. For instance, could it be that 3-vertex- possibly the only fundamental vertex, correspond to this process and could higher vertices have an interpretation in terms of the hierarchy of Planck constants? This would mean analogy with Jones inclusions for which $n \geq 3$ holds true. The assumption that exact fractionization of quantum numbers takes place is not consistent with the identification in terms of Feynman diagrams. Also the huge values of $n_a n_b$ disfavor this identification unless one restricts it to $n_a n_b = 2$.

The considerations of [K13] suggest that in the vertices of generalized Feynman diagrams a re-distribution of the sheets of the coverings can take place in such a manner that the total number of sheets is conserved. The leakage of between different sectors of WCW would in turn mean analogs of self-energy vertices in which n_a and n_b are replaced with their factors or with integers containing them as factors.

1.1.6 Mersenne hypothesis

The generalization of the imbedding space means a book like structure for which the pages are products of singular coverings or factor spaces of CD (causal diamond defined as intersection of future and past directed light-cones) and of CP_2 [K12]. This predicts that Planck constants are rationals and that given value of Planck constant corresponds to an infinite number of different pages of the Big Book, which might be seen as a drawback. If only singular covering spaces are allowed the values of Planck constant are products of integers and given value of Planck constant corresponds to a finite number of pages given by the number of decompositions of the integer to two different integers.

TGD inspired quantum biology and number theoretical considerations suggest preferred values for $r = \hbar/\hbar_0$. For the most general option the values of $\hbar$ are products and ratios of two integers n_a and n_b. Ruler and compass integers defined by the products of distinct Fermat primes and power of two are number theoretically favored values for these integers because the phases $exp(i2\pi/n_i)$, $i \in \{a, b\}$, in this case are number theoretically very simple and should have emerged first in the number theoretical evolution via algebraic extensions of p-adics and of rationals. p-Adic length scale hypothesis favors powers of two as values of r.

One can however ask whether a more precise characterization of preferred Mersennes could exist and whether there could exists a stronger correlation between hierarchies of p-adic length scales and Planck constants. Mersenne primes $M_k = 2^k - 1$, $k \in \{89, 107, 127\}$, and Gaussian Mersennes $M_{G,k} = (1+i)k - 1$, $k \in \{113, 151, 157, 163, 167, 239, 241..\}$ are expected to be physically highly interesting and up to $k = 127$ indeed correspond to elementary particles. The number theoretical miracle is that all the four scaled up electron Compton lengths with $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μm). The question has been whether these define scaled up copies of electro-weak and QCD type physics with ordinary value of $\hbar$. The proposal that this is the case and that these physics are in a well-defined sense induced by the dark scaled up variants of corresponding lower level physics leads to a prediction for the preferred values of $r = 2^{k_d}$, $k_d = k_i - k_j$.

What induction means is that dark variant of exotic nuclear physics induces exotic physics with ordinary value of Planck constant in the new scale in a resonant manner: dark gauge bosons transform to their ordinary variants with the same Compton length. This transformation is natural since in length scales below the Compton length the gauge bosons behave as massless and free particles. As a consequence, lighter variants of weak bosons emerge and QCD confinement scale becomes longer.

This proposal will be referred to as Mersenne hypothesis. It leads to strong predictions about

EEG [K9] since it predicts a spectrum of preferred Josephson frequencies for a given value of membrane potential and also assigns to a given value of $\hbar$ a fixed size scale having interpretation as the size scale of the body part or magnetic body. Also a vision about evolution of life emerges. Mersenne hypothesis is especially interesting as far as new physics in condensed matter length scales is considered: this includes exotic scaled up variants of the ordinary nuclear physics and their dark variants. Even dark nucleons are possible and this gives justification for the model of dark nucleons predicting the counterparts of DNA, RNA, tRNA, and amino-acids as well as realization of vertebrate genetic code [K38].

These exotic nuclear physics with ordinary value of Planck constant could correspond to ground states that are almost vacuum extremals corresponding to homologically trivial geodesic sphere of CP_2 near criticality to a phase transition changing Planck constant. Ordinary nuclear physics would correspond to homologically non-trivial geodesic sphere and far from vacuum extremal property. For vacuum extremals of this kind classical Z^0 field proportional to electromagnetic field is present and this modifies dramatically the view about cell membrane as Josephson junction. The model for cell membrane as almost vacuum extremal indeed led to a quantitative breakthrough in TGD inspired model of EEG and is therefore something to be taken seriously. The safest option concerning empirical facts is that the copies of electro-weak and color physics with ordinary value of Planck constant are possible only for almost vacuum extremals - that is at criticality against phase transition changing Planck constant.

1.2 Some Implications

As already noticed, the detailed implications of the hierarchy of Planck constants depend on whether one brings in the hierarchy of singular coverings and factor spaces of the imbedding space as an independent postulate or whether one assumes that singular coverings emerge as an effective description from basic quantum TGD

1.2.1 Dark variants of nuclear physics

One can imagine endless variety of dark variants of ordinary nuclei and every piece of data is well-come in attempts to avoid a complete inflation of speculative ideas. The book metaphor for the extended imbedding space is useful in the attempts to imagine various exotic phases of matter. For the minimal option atomic nuclei would be ordinary whereas field bodies could be dark and analogous to n-sheeted Riemann surfaces. One can imagine that the nuclei are at the "standard" page of the book and color bonds at different page with different p-adic length scale or having different Planck constant $\hbar$. This would give two hierarchies of nuclei with increasing size.

Color magnetic body of the structure would become a key element in understanding the nuclear binding energies, giant dipole resonances, and nuclear decays. Also other field bodies are in a key role and there seems to be a field body for every basic interaction (classical gauge fields are induced from spinor connection and only four independent field variables are involved so that this is indeed required).

Nothing prevents from generalizing the nuclear string picture so that color bonds could bind also atoms to molecules and molecules to larger structures analogous to nuclei. Even hydrogen bond might be interpreted in this manner. Molecular physics could be seen as a scaled up variant of nuclear physics in a well-defined sense. The exotic features would relate to the hierarchy of various field bodies, including color bonds, electric and weak bonds. These field bodies would play key role also in biology and replaced molecular randomness with coherence in much longer length scale.

In the attempt to make this vision quantitative the starting point is nuclear string model [L2] and the model of cold fusion based on it forcing also to conclude the scaled variants of electro-weak bosons are involved. The model of cold fusion requires the presence of a variant electro-weak interactions for which weak bosons are effectively massless below the atomic length scale.

$k = 113$ p-adically scaled up variant of ordinary weak physics which is dark and corresponds to $\hbar = r\hbar_0$, $r = 2^{k_d}$, $k_d = 14 = 127 - 113$ is an option consistent with Mersenne hypothesis and gives weak bosons in electron length scale. Another possibility is defined by $k = 113$ and $k_d = 24 = 113 - 89 = 151 - 127$ and corresponds to the p-adic length scale $k = 137$ defining atomic

length scale. This would give rise to weak bosons with masses in keV scale and these would be certainly relevant for the physics of condensed matter.

Anomalies of water could be understood if one assumes that color bonds can become dark with suitable values of $r = 2^{k_d}$ and if super-nuclei formed by connecting different nuclei by the color bonds are possible. Tetrahedral and icosahedral water clusters could be seen as magic super-nuclei in this framework. Color bonds could connect either proton nuclei or water molecules.

The model for partially dark condensed matter deriving from exotic nuclear physics and exotic weak interactions could allow to understand the low compressibility of the condensed matter as being due to the repulsive weak force between exotic quarks, explains large parity breaking effects in living matter (chiral selection), and suggests a profound modification of the notion of chemical bond having most important implications for bio-chemistry and understanding of bio-chemical evolution.

1.2.2 Could the notion of dark atom make sense?

One can also imagine several variants of dark atom. Book metaphor suggest one variant of dark atom.

1. Nuclei and electrons could be ordinary but classical electromagnetic interactions are mediated via dark space-time sheet "along different page of the book". The value of Planck constant would be scaled so that one would obtain a hierarchy of scaled variants of hydrogen atom. The findings of [D20] could find an explanation in terms of a reduced Planck constant if singular factor spaces are assumed to be possible. An alternative explanation is based on the notion of quantum-hydrogen atom obtained as q-deformation of the ordinary hydrogen atom.

2. A more exotic variant if atom is obtained by assuming ordinary nuclei but dark, not totally quantum critical, electrons. Dark space-time surface is analogous to n-sheeted Riemann surface and if one assumes that each sheet could carry electron, one ends up with the notion of N-atom. This variant of dark atom is more or less equivalent with that following from the option for which the singular coverings of imbedding space are effective manner to describe the many-valuedness of the time derivatives of the imbedding space coordinates as functions of canonical momentum densities.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at `http://tgdtheory.fi/tgdglossary.pdf` [L3].

2 A Generalization Of The Notion Of Imbedding Space As ARealization Of The Hierarchy Of Planck Constants

2.1 Hierarchy Of Planck Constants And The Generalization Of The Notion Of Imbedding Space

In the following the recent view about structure of imbedding space forced by the quantization of Planck constant is summarized. The question is whether it might be possible in some sense to replace H or its Cartesian factors by their necessarily singular multiple coverings and factor spaces. One can consider two options: either M^4 or the causal diamond CD. The latter one is the more plausible option from the point of view of WCW geometry.

2.1.1 The evolution of physical ideas about hierarchy of Planck constants

The evolution of the physical ideas related to the hierarchy of Planck constants and dark matter as a hierarchy of phases of matter with non-standard value of Planck constants was much faster than the evolution of mathematical ideas and quite a number of applications have been developed during last five years.

1. The starting point was the proposal of Nottale [E1] that the orbits of inner planets correspond to Bohr orbits with Planck constant $\hbar_{gr} = GMm/v_0$ and outer planets with Planck constant $\hbar_{gr} = 5GMm/v_0$, $v_0/c \simeq 2^{-11}$. The basic proposal [K30] was that ordinary matter condenses around dark matter which is a phase of matter characterized by a non-standard value of Planck constant whose value is gigantic for the space-time sheets mediating gravitational interaction. The interpretation of these space-time sheets could be as magnetic flux quanta or as massless extremals assignable to gravitons.

2. Ordinary particles possibly residing at these space-time sheet have enormous value of Compton length meaning that the density of matter at these space-time sheets must be very slowly varying. The string tension of string like objects implies effective negative pressure characterizing dark energy so that the interpretation in terms of dark energy might make sense [K31]. TGD predicted a one-parameter family of Robertson-Walker cosmologies with critical or over-critical mass density and the "pressure" associated with these cosmologies is negative.

3. The quantization of Planck constant does not make sense unless one modifies the view about standard space-time is. Particles with different Planck constant must belong to different worlds in the sense local interactions of particles with different values of $\hbar$ are not possible. This inspires the idea about the book like structure of the imbedding space obtained by gluing almost copies of H together along common "back" and partially labeled by different values of Planck constant.

4. Darkness is a relative notion in this framework and due to the fact that particles at different pages of the book like structure cannot appear in the same vertex of the generalized Feynman diagram. The phase transitions in which partonic 2-surface X^2 during its travel along X^3_l leaks to another page of book are however possible and change Planck constant. Particle (say photon -) exchanges of this kind allow particles at different pages to interact. The interactions are strongly constrained by charge fractionization and are essentially phase transitions involving many particles. Classical interactions are also possible. It might be that we are actually observing dark matter via classical fields all the time and perhaps have even photographed it [K35].

5. The realization that non-standard values of Planck constant give rise to charge and spin fractionization and anyonization led to the precise identification of the prerequisites of anyonic phase [K26]. If the partonic 2-surface, which can have even astrophysical size, surrounds the tip of CD, the matter at the surface is anyonic and particles are confined at this surface. Dark matter could be confined inside this kind of light-like 3-surfaces around which ordinary matter condenses. If the radii of the basic pieces of these nearly spherical anyonic surfaces - glued to a connected structure by flux tubes mediating gravitational interaction - are given by Bohr rules, the findings of Nottale [E1] can be understood. Dark matter would resemble to a high degree matter in black holes replaced in TGD framework by light-like partonic 2-surfaces with a minimum size of order Schwartschild radius r_S of order scaled up Planck length $l_{Pl} = \sqrt{\hbar_{gr} G} = GM$. Black hole entropy is inversely proportional to $\hbar$ and predicted to be of order unity so that dramatic modification of the picture about black holes is implied.

6. Perhaps the most fascinating applications are in biology. The anomalous behavior ionic currents through cell membrane (low dissipation, quantal character, no change when the membrane is replaced with artificial one) has a natural explanation in terms of dark supra currents. This leads to a vision about how dark matter and phase transitions changing the value of Planck constant could relate to the basic functions of cell, functioning of DNA and amino-acids, and to the mysteries of bio-catalysis. This leads also a model for EEG interpreted as a communication and control tool of magnetic body containing dark matter and using biological body as motor instrument and sensory receptor. One especially amazing outcome is the emergence of genetic code of vertebrates from the model of dark nuclei as nuclear strings [L2, K35], [L2].

2.1.2 The most general option for the generalized imbedding space

Simple physical arguments pose constraints on the choice of the most general form of the imbedding space.

1. The fundamental group of the space for which one constructs a non-singular covering space or factor space should be non-trivial. This is certainly not possible for M^4, CD, CP_2, or H. One can however construct singular covering spaces. The fixing of the quantization axes implies a selection of the sub-space $H_4 = M^2 \times S^2 \subset M^4 \times CP_2$, where S^2 is geodesic sphere of CP_2. $\hat{M}^4 = M^4 \backslash M^2$ and $\hat{CP}_2 = CP_2 \backslash S^2$ have fundamental group Z since the codimension of the excluded sub-manifold is equal to two and homotopically the situation is like that for a punctured plane. The exclusion of these sub-manifolds defined by the choice of quantization axes could naturally give rise to the desired situation.

2. CP_2 allows two geodesic spheres which left invariant by $U(2$ *resp.* $SO(3)$. The first one is homologically non-trivial. For homologically non-trivial geodesic sphere $H_4 = M^2 \times S^2$ represents a straight cosmic string which is non-vacuum extremal of Kähler action (not necessarily preferred extremal). One can argue that the many-valuedness of $\hbar$ is un-acceptable for non-vacuum extremals so that only homologically trivial geodesic sphere S^2 would be acceptable. One could go even further. If the extremals in $M^2 \times CP_2$ can be preferred non-vacuum extremals, the singular coverings of M^4 are not possible. Therefore only the singular coverings and factor spaces of CP_2 over the homologically trivial geodesic sphere S^2 would be possible. This however looks a non-physical outcome.

   (a) The situation changes if the extremals of type $M^2 \times Y^2$, Y^2 a holomorphic surface of CP_3, fail to be hyperquaternionic. The tangent space M^2 represents hypercomplex sub-space and the product of the Kähler-Dirac gamma matrices associated with the tangent spaces of Y^2 should belong to M^2 algebra. This need not be the case in general.

   (b) The situation changes also if one reinterprets the gluing procedure by introducing scaled up coordinates for M^4 so that metric is continuous at $M^2 \times CP_2$ but CDs with different size have different sizes differing by the ratio of Planck constants and would thus have only piece of lower or upper boundary in common.

3. For the more general option one would have four different options corresponding to the Cartesian products of singular coverings and factor spaces. These options can be denoted by $C-C$, $C-F$, $F-C$, and $F-F$, where C (F) signifies for covering (factor space) and first (second) letter signifies for CD (CP_2) and correspond to the spaces $(\hat{CD}\hat{\times}G_a) \times (\hat{CP}_2\hat{\times}G_b)$, $(\hat{CD}\hat{\times}G_a) \times \hat{CP}_2/G_b$, $\hat{CD}/G_a \times (\hat{CP}_2\hat{\times}G_b)$, and $\hat{CD}/G_a \times \hat{CP}_2/G_b$.

4. The groups G_i could correspond to cyclic groups Z_n. One can also consider an extension by replacing M^2 and S^2 with its orbit under more general group G (say tetrahedral, octahedral, or icosahedral group). One expects that the discrete subgroups of $SU(2)$ emerge naturally in this framework if one allows the action of these groups on the singular sub-manifolds M^2 or S^2. This would replace the singular manifold with a set of its rotated copies in the case that the subgroups have genuinely 3-dimensional action (the subgroups which corresponds to exceptional groups in the ADE correspondence). For instance, in the case of M^2 the quantization axes for angular momentum would be replaced by the set of quantization axes going through the vertices of tetrahedron, octahedron, or icosahedron. This would bring non-commutative homotopy groups into the picture in a natural manner.

2.1.3 About the phase transitions changing Planck constant

There are several non-trivial questions related to the details of the gluing procedure and phase transition as motion of partonic 2-surface from one sector of the imbedding space to another one.

1. How the gluing of copies of imbedding space at $M^2 \times CP_2$ takes place? It would seem that the covariant metric of CD factor proportional to $\hbar^2$ must be discontinuous at the singular manifold since only in this manner the idea about different scaling factor of CD metric can make sense. On the other hand, one can always scale the M^4 coordinates so that the metric

is continuous but the sizes of CDs with different Planck constants differ by the ratio of the Planck constants.

2. One might worry whether the phase transition changing Planck constant means an instantaneous change of the size of partonic 2-surface in M^4 degrees of freedom. This is not the case. Light-likeness in $M^2 \times S^2$ makes sense only for surfaces $X^1 \times D^2 \subset M^2 \times S^2$, where X^1 is light-like geodesic. The requirement that the partonic 2-surface X^2 moving from one sector of H to another one is light-like at $M^2 \times S^2$ irrespective of the value of Planck constant requires that X^2 has single point of M^2 as M^2 projection. Hence no sudden change of the size X^2 occurs.

3. A natural question is whether the phase transition changing the value of Planck constant can occur purely classically or whether it is analogous to quantum tunnelling. Classical non-vacuum extremals of Chern-Simons action have two-dimensional CP_2 projection to homologically non-trivial geodesic sphere S^2_I. The deformation of the entire S^2_I to homologically trivial geodesic sphere S^2_{II} is not possible so that only combinations of partonic 2-surfaces with vanishing total homology charge (Kähler magnetic charge) can in principle move from sector to another one, and this process involves fusion of these 2-surfaces such that CP_2 projection becomes single homologically trivial 2-surface. A piece of a non-trivial geodesic sphere S^2_I of CP_2 can be deformed to that of S^2_{II} using 2-dimensional homotopy flattening the piece of S^2 to curve. If this homotopy cannot be chosen to be light-like, the phase transitions changing Planck constant take place only via quantum tunnelling. Obviously the notions of light-like homotopies (cobordisms) are very relevant for the understanding of phase transitions changing Planck constant.

2.1.4 How one could fix the spectrum of Planck constants?

The question how the observed Planck constant relates to the integers n_a and n_b defining the covering and factors spaces, is far from trivial and I have considered several options. The basic physical inputs are the condition that scaling of Planck constant must correspond to the scaling of the metric of CD (that is Compton lengths) on one hand and the scaling of the gauge coupling strength $g^2/4\pi\hbar$ on the other hand.

1. One can assign to Planck constant to both CD and CP_2 by assuming that it appears in the commutation relations of corresponding symmetry algebras. Algebraist would argue that Planck constants $\hbar(CD)$ and $\hbar(CP_2)$ must define a homomorphism respecting multiplication and division (when possible) by G_i. This requires $r(X) = \hbar(X)\hbar_0 = n$ for covering and $r(X) = 1/n$ for factor space or vice versa.

2. If one assumes that $\hbar^2(X)$, $X = M^4$, CP_2 corresponds to the scaling of the covariant metric tensor g_{ij} and performs an over-all scaling of H-metric allowed by the Weyl invariance of Kähler action by dividing metric with $\hbar^2(CP_2)$, one obtains the scaling of M^4 covariant metric by $r^2 \equiv \hbar^2/\hbar_0^2 = \hbar^2(M^4)/\hbar^2(CP_2)$ whereas CP_2 metric is not scaled at all.

3. The condition that $\hbar$ scales as n_a is guaranteed if one has $\hbar(CD) = n_a\hbar_0$. This does not fix the dependence of $\hbar(CP_2)$ on n_b and one could have $\hbar(CP_2) = n_b\hbar_0$ or $\hbar(CP_2) = \hbar_0/n_b$. The intuitive picture is that n_b- fold covering gives in good approximation rise to n_an_b sheets and multiplies YM action action by n_an_b which is equivalent with the $\hbar = n_an_b\hbar_0$ if one effectively compresses the covering to $CD \times CP_2$. One would have $\hbar(CP_2) = \hbar_0/n_b$ and $\hbar = n_an_b\hbar_0$. Note that the descriptions using ordinary Planck constant and coverings and scaled Planck constant but contracting the covering would be alternative descriptions.

   This gives the following formulas $r \equiv \hbar/\hbar_0 = r(M^4)/r(CP_2)$ in various cases.

	$C-C$	$F-C$	$C-F$	$F-F$
r	n_an_b	$\frac{n_a}{n_b}$	$\frac{n_b}{n_a}$	$\frac{1}{n_an_b}$

2.1.5 Preferred values of Planck constants

Number theoretic considerations favor the hypothesis that the integers corresponding to Fermat polygons constructible using only ruler and compass and given as products $n_F = 2^k \prod_s F_s$, where $F_s = 2^{2^s} + 1$ are distinct Fermat primes, are favored. The reason would be that quantum phase $q = exp(i\pi/n)$ is in this case expressible using only iterated square root operation by starting from rationals. The known Fermat primes correspond to $s = 0, 1, 2, 3, 4$ so that the hypothesis is very strong and predicts that p-adic length scales have satellite length scales given as multiples of n_F of fundamental p-adic length scale. $n_F = 2^{11}$ corresponds in TGD framework to a fundamental constant expressible as a combination of Kähler coupling strength, CP_2 radius and Planck length appearing in the expression for the tension of cosmic strings, and the powers of 2^{11} was proposed to define favored as values of n_a in living matter [K9].

The hypothesis that Mersenne primes $M_k = 2^k - 1$, $k \in \{89, 107, 127\}$, and Gaussian Mersennes $M_{G,k} = (1+i)k - 1$, $k \in \{113, 151, 157, 163, 167, 239, 241..\}$ (the number theoretical miracle is that all the four scaled up electron Compton lengths $L_e(k) = \sqrt{5}L(k)$ with $k \in \{151, 157, 163, 167\}$ are in the biologically highly interesting range 10 nm-2.5 μm) define scaled up copies of electroweak and QCD type physics with ordinary value of $\hbar$ and that these physics are induced by dark variants of corresponding lower level physics leads to a prediction for the preferred values of $r = 2^{k_d}$, $k_d = k_i - k_j$, and the resulting picture finds support from the ensuing models for biological evolution and for EEG [K9]. This hypothesis - to be referred to as Mersenne hypothesis - replaces the rather ad hoc proposal $r = \hbar/\hbar_0 = 2^{11k}$ for the preferred values of Planck constant.

2.1.6 How Planck constants are visible in Kähler action?

$\hbar(M^4)$ and $\hbar(CP_2)$ appear in the commutation and anti-commutation relations of various superconformal algebras. Only the ratio of M^4 and CP_2 Planck constants appears in Kähler action and is due to the fact that the M^4 and CP_2 metrics of the imbedding space sector with given values of Planck constants are proportional to the corresponding Planck. This implies that Kähler function codes for radiative corrections to the classical action, which makes possible to consider the possibility that higher order radiative corrections to functional integral vanish as one might expect at quantum criticality. For a given p-adic length scale space-time sheets with all allowed values of Planck constants are possible. Hence the spectrum of quantum critical fluctuations could in the ideal case correspond to the spectrum of $\hbar$ coding for the scaled up values of Compton lengths and other quantal lengths and times. If so, large $\hbar$ phases could be crucial for understanding of quantum critical superconductors, in particular high T_c superconductors.

3 General Ideas About Dark Matter

In the sequel general ideas about the role of dark matter in condensed matter physics are described.

3.1 How The Scaling Of $\hbar$ Affects Physics And How To Detect Dark Matter?

It is relatively easy to deduce the basic implications of the scaling of $\hbar$.

1. If the rate for the process is non-vanishing classically, it is not affected in the lowest order. For instance, scattering cross sections for say electron-electron scattering and e^+e^- annihilation are not affected in the lowest order since the increase of Compton length compensates for the reduction of α_{em}. Photon-photon scattering cross section, which vanishes classically and is proportional to $\alpha_{em}^4\hbar^2/E^2$, scales down as $1/\hbar^2$.

2. Higher order corrections coming as powers of the gauge coupling strength α are reduced since $\alpha = g^2/4\pi\hbar$ is reduced. Since one has $\hbar_s/\hbar = \alpha Q_1 Q_2/v_0$, $\alpha Q_1 Q_2$ is effectively replaced with a universal coupling strength v_0. In the case of QCD the paradoxical sounding implication is that α_s would become very small.

3.2 General View About Dark Matter Hierarchy And Interactions Between Relatively Dark Matters

The identification of the precise criterion characterizing dark matter phase is far from obvious. TGD actually suggests an infinite number of phases which are dark relative to each other in some sense and can transform to each other only via a phase transition which might be called de-coherence or its reversal and which should be also characterized precisely.

A possible solution of the problem comes from the general construction recipe for S-matrix. Fundamental vertices correspond to partonic 2-surfaces representing intersections of incoming and outgoing light-like partonic 3-surfaces.

1. If the characterization of the interaction vertices involves all points of partonic 2-surfaces, they must correspond to definite value of Planck constants and more precisely, definite groups G_a and G_b characterizing dark matter hierarchy. Particles of different G_b phases could not appear in the same vertex since the partons in question would correspond to vacuum extremals. Hence the phase transition changing the particles to each other analogous could not be described by a vertex and would be analogous to a de-coherence.

   The phase transition could occur at the incoming or outgoing particle lines. At space-time level the phase transition would mean essentially a leakage between different sectors of imbedding space and means that partonic 2-surface at leakage point has CP_2 projection reducing to the orbifold point invariant under G or alternatively, its $M^4_\pm$ projection corresponds to the tip of $M^4_\pm$. Relative darkness would certainly mean different groups G_a and G_b. Note that $\hbar(M^4)$ *resp.* $\hbar(CP_2)$ can be same for different groups G_a *resp.* G_b and that only the ratio of $\hbar(M^4)/\hbar(M^4)$ appears in the Kähler action.

2. One can represent a criticism against the idea that relatively dark matters cannot appear at the same interaction vertex. The point is that the construction of S-matrix for transitions transforming partonic 2-surfaces in different number fields involves only the rational (algebraic) points in the intersection of the 2-surfaces in question. This idea applies also to the case in which particles correspond to different values of Planck constant. What is only needed that all the common points correspond to the orbifold point in M^4 or CP_2 degrees of freedom and are thus intermediate between two sectors of imbedding space. In this picture phase transitions would occur through vertices and S-matrix would characterize their probabilities. It seems that this option is the correct one.

If the matrix elements for real-real transitions involve all or at least a circle of the partonic 2-surface as stringy considerations suggest [K6], then one would have clear distinction between quantum phase transitions and ordinary quantum transitions. Note however that one could understand the weakness of the quantal interactions between relatively dark matters solely from the fact that the CP_2 type extremals providing space-time correlates for particle propagators must in this case go through an intermediate state with at most point-like CP_2 projection.

3.2.1 What does one mean with dark variants of elementary particle?

It is not at all clear what one means with the dark variant of elementary particle. In this respect p-adic mass calculations provide a valuable hint. According to the p-adic mass calculations [K24], $k = 113$ characterizes electromagnetic size of u and d quarks, of nucleons, and nuclei. $k = 107$ characterizes the QCD size of hadrons. This is somewhat paradoxical situation since one would expect that quark space-time sheets would be smaller than hadronic space-time sheets.

The simplest resolution of the problem suggested by the basic characteristics of electro-weak symmetry breaking is that $k = 113$ characterizes the size of the electro-magnetic field body of the quark and that the prime characterizing p-adic mass scale labels the em field body of the particle. One can assign mass also the Z^0 body but this would be much smaller as the small scale of neutrino masses suggests. This size scale correspond to a length scale of order 10 μm, which conforms with the expectation that classical Z^0 force is important in biological length scales. The size of Z^0 body of neutrino could relate directly to the chirality selection in living matter. An interesting question is whether the Z^0 field bodies of also other elementary fermions are of this size.

If this picture is correct then dark variant of elementary particle would differ from ordinary only in the sense that its field body would be dark. This conforms with the general working hypothesis is that only field bodies can be dark.

3.2.2 Are particles characterized by different p-adic primes relatively dark?

Each particle is characterized by a collection of p-adic primes corresponding to the partonic 2-surfaces associate with the particle like 3-surface. Number theoretical vision supports the notion of multi-p p-adicity and the idea that elementary particles correspond to infinite primes, integers, or perhaps even rationals [K14, K33]. To infinite primes, integers, and rationals it is possible to associate a finite rational $q = m/n$ by a homomorphism. This would suggest generalization of p-adicity with q-adicity (q-adic topology does not correspond to number field) but this does not seem to be a promising idea.

The crucial observation is that one can decompose the infinite prime, call it P, to finite and infinite parts and distinguish between bosonic and fermionic finite primes of which infinite prime can be said to consist of [K39, K33, K25]. The interpretation is that bosonic and fermionic finite primes in the *infinite* part of P code for p-adic topologies of light-like partonic 3-surfaces associated with a given *real* space-time sheet whereas the primes in the *finite* part of P code for p-adic light-like partonic 3-surfaces.

This raises two options.

1. Two space-time sheets characterized by rationals having common prime factors can be connected by a $\#_B$ contact and can interact by the exchange of particles characterized by divisors of m or n since in this case partonic 2-surface with same p-adic or effective p-adic topology can be found. This is the only possible interaction between them.

2. The number theoretic vision about the construction of S-matrix however allows to construct S-matrix also in the case that partons belong to different number fields and one ends up with a very elegant description involving only finite number of points of partonic 2-surfaces belonging to their intersection consisting of rational (algebraic points of imbedding space), which by algebraic universality could apply also to diagonal transitions. Also now the interactions mediated between propagators connecting partons with different effective p-adic topologies might be very slow so that this would give rise to relative darkness.

3.2.3 Hierarchy of infinite primes and dark matter hierarchy

In previous consideration only the simplest infinite primes at the lowest level of hierarchy were considered. Simple infinite primes allow a symmetry changing the sign of the finite part of infinite prime. A possible interpretation in terms of phase conjugation. One can consider also more complex infinite primes at this level and a possible interpretation in terms of bound states of several particles. One can also consider infinite integers and rationals: the interpretation would be as many particle states. Rationals might correspond to states containing particles and antiparticles. At the higher levels of the hierarchy infinite primes of previous take the role of finite primes at the previous level and physically these states correspond to higher level bound states of the particles of the previous level.

Thus TGD predicts an entire hierarchy of dark matters such that the many particle states at previous level become particles at the next level. This hierarchy would provide a concrete physical identification for the hierarchy of infinite primes identifiable in terms of a repeated second quantization of an arithmetic super-symmetric QFT [K33] including both free many-particle states and their bound states. The finite primes about which infinite prime is in a well defined sense a composite of would correspond to the particles in the state forming a unit of dark matter. Particles belonging to different levels of this hierarchy would obviously correspond to different levels of dark matter hierarchy but their interactions must reduce to the fundamental partonic vertices.

3.3 How Dark Matter And Visible Matter Interact?

The hypothesis that the value of $\hbar$ is dynamical, quantized and becomes large at the verge of a transition to a non-perturbative phase in the ordinary sense of the word has fascinating implications. In particular, dark matter, would correspond to a large value of $\hbar$ and could be responsible

for the properties of the living matter. In order to test the idea experimentally, a more concrete model for the interaction of ordinary matter and dark matter must be developed and here of course experimental input and the consistency with the earlier quantum model of living matter is of considerable help.

3.3.1 How dark photons transform to ordinary photons?

The transitions of dark atoms naturally correspond to coherent transitions of the entire dark electron BE condensate and thus generate N_{cr} dark photons and behave thus like laser beams. Dark photons do not interact directly with the visible matter. An open question is whether even ordinary laser beams could be identified as beams of dark photons: the multiple covering property at the level of imbedding space and the fact that MEs are possible in all sectors suggests that this is not the case. Note that the transition from dark to ordinary photons implies the scaling of wave length and thus also of coherence length by a factor n_b/n_a.

Dark $\leftrightarrow$ visible transition should have also a space-time correlate. The so called topological light rays or MEs ("massless extremals") represent a crucial deviation of TGD from Maxwell's ED and have all the properties characterizing macroscopic classical coherence. Therefore MEs are excellent candidates for the space-time correlate of BE condensate of dark photons.

MEs carry in general a superposition of harmonics of some basic frequency determined by the length of ME. A natural expectation is that the frequency of classical field corresponds to the generalized de Broglie frequency of dark photon and is thus $\hbar/\hbar_s$ times lower than for ordinary photons. In completely analogous manner de Broglie wave length is scaled up by $k = \hbar_s/\hbar$. Classically the decay of dark photons to visible photons would mean that an oscillation with frequency f inside topological light ray transforms to an oscillation of frequency f/k such that the intensity of the oscillation is scaled up by a factor k. Furthermore, the ME in question could naturally decompose into $1 < N_{cr} \leq 137$ ordinary photons in the case that dark atoms are in question. Of course also MEs could decay to lower level MEs and this has an interpretation in terms of hierarchy of dark matters to be discussed next.

3.3.2 About the criterion for the transition increasing the value of Planck constant

An attractive assumption is that the transition to dark matter phase occurs when the interaction strength satisfies the criticality condition $Q_1Q_2\alpha \simeq 1$. A special case corresponds to self interaction with $Q_1 = Q_2$. This condition applies only to gauge interactions so that particles can be characterized by gauge charges. A more general characterization would be that transition occurs when perturbation theory ceases to converge. The criterion cannot be applied to phenomenological QFT description of strong force in terms of, say, pion exchange.

Some examples are in order to test this view.

1. Transition from perturbative phase in QCD to hadronic phase is the most obvious application. The identification of valence quarks and gluons as dark matter would predict for them QCD size ($k = 107$ space-time sheet) of about electron Compton length. This does not change the QCD cross sections in the lowest order perturbation theory but makes them excellent predictions. It also provides completely new view about how color force determines the nuclear strong force indeed manifesting itself as long ranged harmonic oscillator potential, the long range of which becomes manifest in the case of neutron halos of size of 2.5×10^{-14} m [C21]. One can also understand tetraneutron in this framework. This criterion applies also in QCD plasma and explains the formation of liquid like color glass condensate detected in RHIC [C20]. A possible interpretation for QCD size would be as a length of the cylindrical magnetic walls defining the magnetic body associated with u and d type valence quarks, nucleons, and nuclei.

2. QCD size of quark must be distinguished from the electromagnetic size of quark associated with $k = 113$ space-time sheets of u and d quarks and assignable to the height of the magnetic body and defining the length scale of flux tubes feeding quark charges to $k = 113$ space-time sheets.

3. In the case of atomic nuclei the criterion would naturally apply to the electromagnetic interaction energy of two nucleon clusters inside nucleus or to to self energy ($Q^2\alpha_{em} = 1$). Quite

generally, the size of the electromagnetic $k = 113$ space-time sheet would increase by a $n_F = 2^k \prod_s F_s$, where F_s are different Fermat primes (the known ones being $3, 5, 17, 257, 2^{16} + 1$), in the transition to large $\hbar$ phase. Especially interesting values of n_F seem to be of form $n_F = 2^{k11}$ and possibly also $n_F = 2^{k11} \prod_s F_s$. Similar criterion would apply in the plasma phase. Note that many free energy anomalies involve the formation of cold plasma [K34].

The criterion would give in the case of single nucleus and plasma $Z \geq 12$ if the charges are within single space-time sheet. This is consistent with cold fusion involving Palladium nuclei [C7]. Since u and d quarks have $k = 113$, they both and thus both neutrons and protons could make a transition to large $\hbar$ phase. This is consistent with the selection rules of cold fusion since the production of ^3He involves a phase transition $\mathrm{pnp}_d \rightarrow \mathrm{pnp}$ and the contraction of p_d to p is made un-probable by the Coulomb wall whereas the transition $\mathrm{nnp}_d \rightarrow$nnp producing tritium does not suffer from this restriction.

Strong and weak physics of nuclei would not be affected in the phase transition. Electromagnetic perturbative physics of nuclei would not be affected in the process in the lowest order in $\hbar$ (classical approximation) but the height of the Coulomb wall would be reduced by a factor $1/n_F$ by the increase in the electromagnetic size of the nucleus. Also Pd nuclei could make the transition and Pd nuclei could catalyze the transition in the case the deuterium nuclei.

3.4 Could One Demonstrate The Existence Of Large Planck Constant Photons Using Ordinary Camera Or Even Bare Eyes?

If ordinary light sources generate also dark photons with same energy but with scaled up wavelength, this might have effects detectable with camera and even with bare eyes. In the following I consider in a rather light-hearted and speculative spirit two possible effects of this kind appearing in both visual perception and in photos. For crackpotters I want to make clear that I love to play with ideas to see whether they work or not, and that I am ready to accept some convincing mundane explanation of these effects and I would be happy to hear about this kind of explanations. I was not able to find any such explanation from Wikipedia using words like camera, digital camera, lense, aberrations [D3].

3.4.1 Why light from an intense light source seems to decompose into rays?

If one also assumes that ordinary radiation fields decompose in TGD Universe into topological light rays ("massless extremals", MEs) even stronger predictions follow. If Planck constant equals to $\hbar = q \times \hbar_0$, $q = n_a/n_b$, MEs should possess Z_{n_a} as an exact discrete symmetry group acting as rotations along the direction of propagation for the induced gauge fields inside ME.

The structure of MEs should somewhat realize this symmetry and one possibility is that MEs has a wheel like structure decomposing into radial spokes with angular distance $\Delta\phi = 2\pi/n_a$ related by the symmetries in question. This brings strongly in mind phenomenon which everyone can observe anytime: the light from a bright source decomposes into radial rays as if one were seeing the profile of the light rays emitted in a plane orthogonal to the line connecting eye and the light source. The effect is especially strong if eyes are stirred. It would seem that focusing makes the effect stronger.

Could this apparent decomposition to light rays reflect directly the structure of dark MEs and could one deduce the value of n_a by just counting the number of rays in camera picture, where the phenomenon turned to be also visible? Note that the size of these wheel like MEs would be macroscopic and diffractive effects do not seem to be involved. The simplest assumption is that most of photons giving rise to the wheel like appearance are transformed to ordinary photons before their detection.

The discussions about this led to a little experimentation with camera at the summer cottage of my friend Samppa Pentikäinen, quite a magician in technical affairs. When I mentioned the decomposition of light from an intense light source to rays at the level of visual percept and wondered whether the same occurs also in camera, Samppa decided to take photos with a digital camera directed to Sun. The effect occurred also in this case and might correspond to decomposition to MEs with various values of n_a but with same quantization axis so that the effect is not smoothed out.

What was interesting was the presence of some stronger almost vertical "rays" located symmetrically near the vertical axis of the camera. In old-fashioned cameras the shutter mechanism determining the exposure time is based on the opening of the first shutter followed by closing a second shutter after the exposure time so that every point of sensor receives input for equally long time. The area of the region determining input is bounded by a vertical line. If macroscopic MEs are involved, the contribution of vertical rays is either nothing or all unlike that of other rays and this might somehow explain why their contribution is enhanced. The shutter mechanism is unnecessary in digital cameras since the time for the reset of sensors is what matters. Something in the geometry of the camera or in the reset mechanism must select vertical direction in a preferred position. For instance, the outer "aperture" of the camera had the geometry of a flattened square.

3.4.2 Anomalous diffraction of dark photons

Second prediction is the possibility of diffractive effects in length scales where they should not occur. A good example is the diffraction of light coming from a small aperture of radius d. The diffraction pattern is determined by the Bessel function

$$J_1(x) \ , \ x = kdsin(\theta) \ , \ k = 2\pi/\lambda.$$

There is a strong light spot in the center and light rings around whose radii increase in size as the distance of the screen from the aperture increases. Dark rings correspond to the zeros of $J_1(x)$ at $x = x_n$ and the following scaling law for the nodes holds true

$$sin(\theta_n) = x_n \frac{\lambda}{2\pi d} per.$$

For very small wavelengths the central spot is almost point-like and contains most light intensity.

If photons of visible light correspond to large Planck constant $\hbar = q \times \hbar_0$ transformed to ordinary photons in the detector (say camera film or eye), their wavelength is scaled by q, and one has

$$sin(\theta_n) \to q \times sin(\theta_n)$$

The size of the diffraction pattern for visible light is scaled up by q.

This effect might make it possible to detect dark photons with energies of visible photons and possibly present in the ordinary light.

1. What is needed is an intense light source and Sun is an excellent candidate in this respect. Dark photon beam is also needed and n dark photons with a given visible wavelength λ could result when dark photon with $\hbar = n \times q \times \hbar_0$ decays to n dark photons with same wavelength but smaller Planck constant $\hbar = q \times \hbar_0$. If this beam enters the camera or eye one has a beam of n dark photons which forms a diffraction pattern producing camera picture in the de-coherence to ordinary photons.

2. In the case of an aperture with a geometry of a circular hole, the first dark ring for ordinary visible photons would be at $sin(\theta) \simeq (\pi/36)\lambda/d$. For a distance of $r = 2$ cm between the sensor plane ("film") and effective circular hole this would mean radius of $R \simeq rsin(\theta) \simeq 1.7$ micrometers for micron wave length. The actual size of spots is of order $R \simeq 1$ mm so that the value of q would be around 1000: $q = 2^{10}$ and $q = 2^{11}$ belong to the favored values for q.

3. One can imagine also an alternative situation. If photons responsible for the spot arrive along single ME, the transversal thickness R of ME is smaller than the radius of hole, say of of order of wavelength, ME itself effectively defines the hole with radius R and the value of $sin(\theta_n)$ does not depend on the value of d for $d > R$. Even ordinary photons arriving along MEs of this kind could give rise to an anomalous diffraction pattern. Note that the transversal thickness of ME need not be fixed however. It however seems that MEs are now macroscopic.

4. A similar effect results as one looks at an intense light source: bright spots appear in the visual field as one closes the eyes. If there is some more mundane explanation (I do not doubt

this!), it must apply in both cases and explain also why the spots have precisely defined color rather than being white.

5. The only mention about effects of diffractive aberration effects are colored rings around say disk like objects analogous to colors around shadow of say disk like object. The radii of these diffraction rings in this case scale like wavelengths and distance from the object.

6. Wikipedia contains an article from which one learns that the effect in question is known as lens flares [D7]. The article states that flares typically manifest as several starbursts, circles, and rings across the picture and result in internal reflection and scattering from material inhomogenuities in lens (such as multiple surfaces). The shape of the flares also depends on the shape of aperture. These features conform at least qualitatively with what one would expect from a diffraction if Planck constant is large enough for photons with energy of visible photon.

   The article [D11] defines flares in more restrictive manner: lense flares result when *non-image* forming light enters the lens and subsequently hits the camera's film or digital sensor and produces typically polygonal shape with sides which depend on the shape of lense diaphgram. The identification as a flare applies also to the apparent decomposition to rays and this dependence indeed fits with the observations.

The experimentation of Samppa using digital camera demonstrated the appearance of colored spots in the pictures. If I have understood correctly, the sensors defining the pixels of the picture are in the focal plane and the diffraction for large Planck constant might explain the phenomenon. Since I did not have the idea about diffractive mechanism in mind, I did not check whether fainter colored rings might surround the bright spot.

1. In any case, the readily testable prediction is that zooming to bright light source by reducing the size of the aperture should increase the size and number of the colored spots. As a matter fact, experimentation demonstrated that focusing brought in large number of these spots but we did not check whether the size was increased.

2. Standard explanation predicts that the bright spots are present also with weaker illumination but with so weak intensity that they are not detected by eye. The positions of spots should also depend only on the illumination and camera. The explanation in terms of beams of large Planck constant photons predicts this if the flux of dark photons from any light source is constant.

3.5 Dark Matter And Exotic Color And Electro-Weak Interactions

The presence of classical electro-weak and color gauge fields in all length scales is an unavoidable prediction of TGD and the interpretation in terms of p-adic and dark matter hierarchies is also more or less unavoidable. The new element in the interpretation is based on the observation that the quark and antiquarks at the ends of flux tubes serving as sources of classical color gauge fields could be seen as a vacuum polarization effect. In the same manner neutrino pairs at the ends of flux tubes serving as sources of classical Z^0 fields could be seem as a vacuum polarization effect.

One of the many open questions is whether also p-adic hierarchy defines a hierarchy of confinement scales for color interactions and screening scales for weak interactions or whether only the hierarchy of Planck constants gives rise to this kind of hierarchy. It would look strange if all flux tubes of macroscopic size scale would always correspond to a large value of $\hbar$ and therefore singular covering and fractionized quantum numbers. Also the proposed dark rules involving hierarchy of Mersenne rules would support the view that both hierarchies are present and there is an interaction between them in the sense that phase transitions between dark and thus scaled up counterpart of p-adic length scale and non-dark scaled up p-adic length scale can take place. The proposed stability criteria certainly allow this.

3.5.1 Do p-adic and dark matter hierarchies provide a correct interpretation of long ranged classical electro-weak gauge fields?

For two decades one of the basic interpretational challenges of TGD has been to understand how the un-avoidable presence of long range classical electro-weak gauge fields can be consistent with the

small parity breaking effects in atomic and nuclear length scales. Also classical color gauge fields are predicted, and I have proposed that color qualia correspond to increments of color quantum numbers [K15] . The proposed model for screening cannot banish the unpleasant feeling that the screening cannot be complete enough to eliminate large parity breaking effects in atomic length scales so that one one must keep mind open for alternatives.

p-Adic length scale hypothesis suggests the possibility that both electro-weak gauge bosons and gluons can appear as effectively massless particles in several length scales and there indeed exists evidence that neutrinos appear in several scaled variants [C19] (for TGD based model see [K20]).

This inspires the working hypothesis that long range classical electro-weak gauge and gluon fields are correlates for light or massless p-adically scaled up and dark electro-weak gauge bosons and gluons. Thus both p-adic and dark hierarchies would be involved. For the p-adic hierarchy the masses would be scaled up whereas for the dark hierarchy masses would be same. The essentially new element in the interpretation would be that these fields assignable to flux quanta could be seen as vacuum polarization effects in even macroscopic length scales. This vision would definitely mean new physics effects but the interpretation would be consistent with quantum field theoretic intuition.

1. In this kind of scenario ordinary quarks and leptons could be essentially identical with their standard counterparts with electro-weak charges screened in electro-weak length scale so that the problems related to the smallness of atomic parity breaking would be trivially resolved. The weak form of electric-magnetic duality allows to identify the screening mechanism as analog of confinement mechanism for weak isospin

2. In condensed matter blobs of size larger than neutrino Compton length (about 5 μm if $k = 169$ determines the p-adic length scale of condensed matter neutrinos) the situation could be different. Also the presence of dark matter phases with sizes and neutrino Compton lengths corresponding to the length scales defined as p-adically scaled up electron Compton lengths $L_e(k) = \sqrt{5}L(k)$, $k = 151, 157, 163, 167$ in the range 10 nm-2.5 μm are suggested by the number theoretic considerations (these values of k correspond to so called Gaussian Mersennes [K17]). Only a fraction of the condensed matter consisting of regions of size $L_e(k)$ need to be in the dark phase.

3. Dark quarks and leptons would have masses essentially identical to their standard model counterparts. Only the electro-weak boson masses which are determined by a different mechanism than the dominating contribution to fermion masses [K20, K20] would be small or vanishing. Below the dark or p-adic length scale in question gauge bosons would behave like massless quanta.

4. The large parity breaking effects in living matter would be due to the presence of dark nuclei and leptons. Later the idea that super-fluidity corresponds to Z^0 super-conductivity will be discussed it might be that also super-fluid phase corresponds to dark neutron phase.

The basic prediction of TGD based model of dark matter as a phase with a large value of Planck constant is the scaling up of various quantal length and time scales. Mersenne hypothesis allows a wide range of scales so that very rich structures are possible.

Dark photon many particle states behave like laser beams decaying to ordinary photons by de-coherence meaning a transformation of dark photons to ordinary ones. Also dark electro-weak bosons and gluons would be massless or have small masses determined by the p-adic length scale in question. The decay products of dark electro-weak gauge bosons would be ordinary electro-weak bosons decaying rapidly via virtual electro-weak gauge boson states to ordinary leptons. Topological light rays ("massless extremals") for which all classical gauge fields are massless are natural space-time correlates for the dark boson laser beams. Obviously this means that the basic difference between the chemistries of living and non-living matter would be the absence of electro-weak symmetry breaking in living matter (which does not mean that elementary fermions would be massless).

3.5.2 Criterion for the presence of exotic electro-weak bosons and gluons

Classical gauge fields directly are space-time correlates of quantum states. The gauge fields associated with massless extremals ("topological light rays") decompose to free part and a part

having non-vanishing divergence giving rise to a light-like Abelian gauge current. Free part would correspond to Bose-Einstein condensates and current would define a coherent state of dark photons.

The dimension D of the CP_2 projection of the space-time sheet serves as a criterion for the presence of long ranged classical electro-weak and gluon fields. D also classifies the (possibly asymptotic) solutions of field equations [K4].

1. For $D = 2$ induced gauge fields are Abelian and induced Kähler form vanishes for vacuum extremals: in this case classical em and Z^0 fields are proportional to each other. The non-vanishing Kähler field implies that induced gluon fields are non-vanishing in general. This raises the question whether long ranged color fields and by quantum classical correspondence also long ranged QCD accompany non-vacuum extremals in all length scales. This makes one wonder whether color confinement is possible at all and whether scaled down variants of QCD appear in all length scales.

   The possibility to add constants to color Hamiltonians appearing in the expression of the classical color gauge fields allows to have vanishing color charges in the case of an arbitrary space-time sheet. The requirement that color quantum numbers of the generator vanish allows to add the constant only to the Hamiltonians of color hyper charge and isospin so that for $D = 2$ extremals color charges can be made vanishing. This might allow to understand how color confinement is consistent with long ranged induced Kähler field.

2. For $D \geq 3$ all classical long ranged electro-weak fields and non-Abelian color fields are present. This condition is satisfied when electric and magnetic fields are not orthogonal and the instanton density $A \wedge J$ for induced Kähler form is non-vanishing. The rather strong conclusion is that in length scales in which exotic electro-weak bosons are not present, one has $D = 2$ and gauge fields are Abelian and correspond trivially to fixed points of renormalization group realized as a hydrodynamic flow at space-time sheets [K2].

Quantum classical correspondence suggests the existence of electro-weak gauge bosons with mass scale determined by the size of the space-time sheets carrying classical long range electro-weak fields. This would mean the existence of new kind of gauge bosons.

The obvious objection is that the existence of these gauge bosons would be reflected in the decay widths of intermediate gauge bosons. The remedy of the problem is based on the notion of space-time democracy suggested strongly by the fact that the interactions between space-time sheets possessing different p-adic topologies proceed with very slow rates simply because the number of common rational (algebraic) points of partonic 2-surfaces appearing in the vertex is small.

For light exotic electro-weak bosons also the corresponding leptons and quarks would possess a large weak space-time sheet but lack the ordinary weak partonic 2-surface so that there would be no direct coupling to electro-weak gauge bosons. These space-time sheets are dark in weak sense but need not have a large value of $\hbar$. This picture implies the notion of partial darkness since any space-time sheets with different ordinary of Gaussian primes are dark with respect to each other.

3.5.3 Do Gaussian Mersennes define a hierarchy of dark electro-weak physics?

Gaussian Mersennes are defined as Gaussian primes of form $g_n = (1+i)^n - 1$, where n must be prime. They have norm squared $g\overline{g} = 2^n - 1$. The list of the first Gaussian Mersennes corresponds to the following values of n.

2, 3, 5, 7, 11, 19, 29, 47, 73, 79, 113, 151, 157, 163, 167, 239, 241, 283, 353, 367, 379, 457, 997, 1367, 3041, 10141, 14699, 27529, 49207, 77291, 85237, 106693, 160423 and 203789.

The Gaussian primes $k = 113, 151, 157, 163, 167$ correspond to length scales which are of most obvious interest but in TGD framework one cannot exclude the twin prime $239, 241$ corresponds to length scales $L_e(k) \simeq 160$ km and 320 km. Also larger primes could be of relevant for bio-systems and consciousness. Also the secondary and higher length scales associated with $k < 113$ could be of importance and their are several length scales of this kind in the range of biologically interesting length scales. Physics and biology inspired considerations suggests that particular Gaussian primes correspond to a particular kind of exotic matter, possibly also to large $\hbar$ phase.

$k = 113$ corresponds to the electromagnetic length scale of u and d quarks and nuclear p-adic length scale. For dark matter these length scales are scaled up by a factor $r \sim 2^{k_d}$, with k_d fixed by Mersenne hypothesis.

On basis of biological considerations (large parity breaking in living matter) there is a temptation to assign to these length scales a scaled down copy of electro-weak physics and perhaps also of color physics. The mechanism giving rise to these states would be a phase transition transforming the ordinary $k = 89$ Mersenne of weak space-time sheets to a Gaussian Mersenne and thus increasing its size dramatically.

If given space-time sheet couples considerably only to space-time sheets characterized by same prime or Gaussian prime, the bosons of these physics do not couple directly to ordinary particles, and one avoids consistency problems due to the presence of new light particles (consider only the decay widths of intermediate gauge bosons [K21]) even in the case that the loss of asymptotic freedom is not assumed.

A question arises about the interpretation of structures of the predicted size. The strong interaction size of u and d quarks, hadrons, and nuclei is smaller than $L(k = 113) \simeq 2 \times 10^{-4}$ m for even heaviest nuclei if one accepts the formula $R \sim A^{1/3} \times 1.5 \times 10^{-15}$ m. A natural interpretation for this length scale would be as the size of the field body/magnetic body of system defined by its topologically quantized gauge fields/magnetic parts of gauge fields. The (possibly dark) p-adic length scale characterizes also the lengths of flux tubes feeding gauge fluxes from elementary particle to the space-time sheet in question. The de-localization due these flux tubes in p-adic length scale in question would determine the scale of the contribution to the mass squared of the system as predicted by p-adic thermodynamics.

3.6 Anti-Matter And Dark Matter

The usual view about matter anti-matter asymmetry is that during early cosmology matter-antimatter asymmetry characterized by the relative density difference of order $r = 10^{-9}$ was somehow generated and that the observed matter corresponds to what remained in the annihilation of quarks and leptons to bosons. A possible mechanism inducing the CP asymmetry is based on the CP breaking phase of CKM matrix.

The TGD based view about energy [K37, K31] forces the conclusion that all conserved quantum numbers including the conserved inertial energy have vanishing densities in cosmological length scales. Therefore fermion numbers associated with matter and antimatter must compensate each other. Therefore the standard option seems to be excluded in TGD framework.

The way out could be based on the many-sheeted space-time and the possibility of cosmic strings. One particular TGD inspired model involves a small matter-antimatter asymmetry induced by the Kähler electric fields of cosmic strings [K7]. The topological condensation of fermions and anti-fermions at space-time sheets carrying Kähler electric field of say cosmic string gives rise to a binding energy which is of different sign for fermions and anti-fermions and therefore should induce the asymmetry. The outcome of the annihilation period would be matter outside cosmic strings and antimatter inside them.

One can also imagine that in a given Kähler electric field matter develops large binding energy and antimatter large positive interaction energy which induces instability leading to the splitting of partonic 2-surfaces to dark space-time sheets implying fractionization and reduction of the energy at given sheet of the covering. Dark antimatter would interact very weakly with ordinary matter so that the non-observability of antimatter would find an elegant explanation. One can imagine also the generation of local asymmetries inside Kähler electric flux tubes leading to flux tube states with matter and antimatter condensed at the opposite ends of the flux tubes.

4 Dark Variants Of Nuclear Physics

The book metaphor for the extended imbedding space can be utilized as a guideline as one tries to imagine various exotic phases of matter. For the minimal option atomic nuclei can be assumed to be ordinary (in the sense of nuclear string model [K7] !) and only field bodies can be dark. If only singular coverings of M^4 and CP_2 are allowed the value of Planck constant is product of two integers. Ruler and compass hypothesis restricts these integers considerably and Mersenne

hypothesis provides further constraints on the model. Nuclei can be visualized as residing at the "standard" pages of the book and dark color-/weak-/em- bonds are at different pages with different p-adic length scale or having different Planck constant. This would give two hierarchies of nuclei with increasing size.

4.1 Constraints From The Nuclear String Model

In the case of exotic nuclei nuclear string model [L2], [L2] is a safe starting point. In this model nucleons are connected by color flux tubes having exotic light fermion and anti-fermion at their ends. Whether fermion is quark or colored excitation of lepton remains open question at this stage. The mass of the exotic fermion is much smaller than 1 MeV (p-adic temperature $T = 1/n < 1$). This model predicts large number of exotic states since color bonds, which can be regarded as colored pions, can have em charges (1, -1, 0). In particular, neutral variant of deuterium is predicted and this leads to a model of cold fusion explaining its basic selection rules. The earlier model for cold fusion discussed in [K32], which served as a constraint in the earlier speculations, is not so simple than the model of [L2], [L2].

What is important that the model requires that weak bosons for which Compton length is of order atomic size are involved. Weak bosons would behave as massless particles below the Compton and the rates for the exchanges of weak bosons would be high in the length scales considered. Weak bosons would correspond to scaled up variants of the ordinary weak bosons: scaling could be p-adic in which mass scale is reduced and weak interaction rates even above Compton length would be scaled up as $1/M_W^4$. The scaling could result also from the scaling of Planck constant in which case masses of weak bosons nor weak interaction rates in the lowest order would not be affected. If only dark scaling is involved, weak interactions would be still extremely weak above dark Compton length of weak bosons. Of course, both scalings can be imagined.

The scale of the color binding energy is $E_s = .2$ MeV for ordinary ^4He strings [K7]. $k = 151, 157, 163, 167$ define Gaussian Mersennes $G_{M,k} = (1+i)^k - 1$ and excellent candidates for biologically important p-adic length scales. There are also higher Gaussian Mersennes such as those corresponding to $k = 239, 241$ and also these seem to be interesting biologically (see [K9] where a vision about evolution and generalized EEG based on Gaussian Mersennes is described). Let us assume that these scales and also those corresponding to $k = 89, 107, 113, 127$ allow scaled variants of electroweak and color interactions with ordinary value of Planck constant. If M_{127} is scaled up to Gaussian Mersenne $M_{G,167}$, one obtains cell-nucleus sized (2.58 μm) exotic nuclei and the unit of color binding energy is still.2 eV. For p-adic length scale of order 100 μm (size of large neuron) the energy scale is still around thermal energy at room temperature.

In the case of dark color bonds it is not quite clear how the unit E_s of the color binding energy scales. If color Coulomb energy is in question, one expects $1/\hbar^2$ scaling. Rather remarkably, this scaling predicts that the unit for the energy of $A < 4$ color bond scales down to.5 eV which is the energy of hydrogen bond so that hydrogen bonds, and also other molecular bonds, might involve color bonds between proton and oxygen.

4.2 Constraints From The Anomalous Behavior Of Water

$H_{1.5}O$ behavior of water with respect to neutron and electron scattering is observed in atto-second time scale which corresponds to 3 Angstrom length scale, defining an excellent candidate for the size scale of exotic nuclei and Compton length of exotic weak interactions.

4.2.1 What happens to the invisible protons?

A possible explanation for the findings is that one fourth of protons forms neutral multi-proton states connected by possibly negatively charged color bonds of length differing sufficiently from the length of ordinary O-H bond. Although the protons are ordinary, neutron diffraction reflecting the crystal like order of water in atomic length scales would not see these poly-proton super-nuclei if they form separate closed strings.

1. For the ordinary nuclei the p-adic length scale associated with the color bonds between ^4He corresponds to M_{127}, and one can imagine exotic nuclear strings obtained by connecting two ordinary nuclei with color bonds. If second exotic nucleus is neutral (the model of cold fusion

Table 1: The integers k_{eff} characterize the effective p-adic length scales for some dark variants of color magnetic bodies for ^4He and $A < 4$ color magnetic bodies corresponding to $k \in \{127, 118\}$ and for the dark variants of $k = 116$ electromagnetic body for nuclear strings. Dark variants correspond to $k_d \in \{24 = 113 - 89 = 151 - 127, 20 = 127 - 107, 18 = 107 - 89\}$ allowed by Mersenne hypothesis.

k_d	24	20	18
$k_{eff} = 116 + k_d$	140	136	134

assumes that D nucleus is neutral) this could work since the Coulomb wall is absent. If the exotic nuclei have opposite em charges, the situation improves further. New super-dense phases of condensed matter would be predicted.

If one fourth of hydrogen nuclei of water combine to form possibly neutral nuclear strings with average distance of nuclei of order $L(127)$, they are not visible in diffraction at atomic length scale because the natural length scale is shortened by a factor of order 32 but could be revealed in neutron diffraction at higher momentum exchanges. The transition between this kind of phase and ordinary nuclei would be rather dramatic event and the exchanges of exotic weak bosons with Compton lengths of order atomic size induce the formation of this kind of nuclei (this exchange is assumed in the model of cold fusion).

2. If dark color magnetic bonds are allowed, a natural distance between the building blocks of super-nuclei is given by the size scale of the color magnetic body. In nuclear string model the size scales of color magnetic bodies associated with nuclear strings consisting of ^4He and $A < 4$ nuclei color magnetic bodies correspond to $k = 127$ and $k = 118$ whereas em magnetic body corresponds to $k = 116$ [L2], [L2]. For dark variants of magnetic bodies the sizes of these magnetic bodies are scaled. There are several options to consider: consider only $k_d = 113 - 89 = 24$, $k_d = 127 - 107 = 20$ and $k_d = 107 - 89 = 18$. Note that one has $h_{eff} = nh$, where n is product of distinct Fermat primes and power 2^{k_d}. **Table 1** below summarizes the effective dark p-adic length scales involved.

3. Consider $k_d = 24$ as an example. From **Table 1** the scaled up p-adic length scales of the magnetic bodies would be $L(127 + 24 = 151) = 10$ nm, $L(118 + 24 = 142) = 4.4$ Angstrom, and $L(116 + 24 = 140) = 2.2$ Angstrom. The first scale equals to the thickness of cell membrane which suggests a direct connection with biology. The latter two scales correspond to molecular length scales and it is not clear why the protons of dark nuclear strings of this kind would not be observed in electron and neutron scattering. This would leave only nuclear strings formed from ^4He nuclei into consideration.

   The crucial parameter is the unit E_s of the color binding energy. Since this parameter should correspond to color Coulombic potential it could transform like the binding energy of hydrogen atom and therefore scale as $1/\hbar^2$. This would mean that $E_s = 2.2$ MeV deduced from the deuteron binding energy would scale down to .12 eV for $r = 2^{24}$.

The transition between the dark and ordinary nuclei would be favored by the minimization of Coulomb energy and energy differences would be small because of darkness. The transitions in which ordinary proton becomes dark and fuses to super-nuclear string or vice versa could be the basic control mechanism of bio-catalysis. Metabolic energy quantum.5 eV should relate to this transition.

Magic nuclei could have fractally scaled up variants in molecular length scale and tetrahedral and icosahedral water clusters could correspond to $A = 8$ and $A = 20$ magic nuclei with color bonds connecting nucleons belonging to different dark nuclei.

4.2.2 About the identification of the exotic weak physics?

The model of cold fusion requires exotic weak physics with the range of weak interaction of order atomic radius.

One can consider the possibility of $k = 113$ dark weak physics with $r = 2^{24}$ ($89 \to 113$ in Mersenne hypothesis) implying that the dark weak scale corresponds to p-adic length scale $k = 137$. Weak Compton length for $k = 113$ dark weak bosons would be about 3 Angstrom. Below $L(137)$ weak bosons would behave as massless particles. Above $L(137)$ weak bosons would have the mass scale $2^{-12}m_W \sim 25$ MeV and weak rates would be scaled up by 2^{48}. Bohr radius would represent a critical transition length scale and exotic weak force could have dramatic implications for the behavior of the condensed matter in high pressures when exotic weak force would become visible. In particular, chiral selection in living matter could be understood in terms of large parity breaking implied. These physics would manifest themselves only at criticality for the phase transitions changing Planck constant and would correspond to almost vacuum extremals defining a phase different from that assignable to standard model physics.

To sum up, it would seem that the variant of ordinary nuclear physics obtained by making color bonds and weak bonds dark is the most promising approach to the $H_{1.5}O$ anomaly and cold fusion. Exotic weak bosons with Compton wave length of atomic size and the most natural assumption is that they are dark $k = 113$ weak bosons with $k_d = 24 = 113 - 89$. One variant of exotic atoms is as atoms for which electromagnetic interaction between ordinary nuclei and ordinary electrons is mediated along dark topological field quanta.

4.3 Exotic Chemistries And Electromagnetic Nuclear Darkness

The extremely hostile and highly un-intellectual attitude of skeptics stimulates fear in anyone possessing amygdala, and I am not an exception. Therefore it was a very pleasant surprise to receive an email telling about an article published in April 16, 2005 issue of New Scientist [D30]. The article gives a popular summary about the work of the research group of Walter Knight with Na atom clusters [D19] and of the research group of Welford Castleman with Al atom clusters [D17].

The article tells that during last two decades a growing evidence for a new kind of chemistry have been emerging. Groups of atoms seem to be able to mimic the chemical behavior of single atom. For instance, clusters of 8, 20, 40, 58 or 92 sodium atoms mimic the behavior of noble gas atoms [D19]. By using oxygen to strip away electrons one by one from clusters of Al atoms it is possible to make the cluster to mimic entire series of atoms [D17]. For aluminium cluster-ions made of 13, 23 and 37 atoms plus an extra electron are chemically inert.

One can imagine two explanations for the findings.

1. The nuclei are dark in the sense that the sizes of nuclear space-time sheets are scaled up implying the smoothing out of the nuclear charge.

2. Only electrons are dark in the sense of having scaled up Compton lengths so that the size of multi-electron bound states is not smaller than electron Compton length and electrons "see" multi-nuclear charge distribution.

If darkness and Compton length is assigned with the em field body, it becomes a property of interaction, and it seems impossible to distinguish between options 1) and 2).

4.3.1 What one means with dark nuclei and electrons?

Can the idea about dark nuclei and electrons be consistent with the minimalist picture in which only field bodies are dark? Doesn't the darkness of nucleus or electron mean that also multi-electron states with n electrons are possible?

The proper re-interpretation of the notion Compton length would allow a consistency with the minimalist scenario. If the p-adic prime labelling the particle actually labels its electromagnetic body as p-adic mass calculations for quark masses encourage to believe, Compton length corresponds to the size scale of the electromagnetic field body and the models discussed below would be consistent with the minimal scenario. Electrons indeed "see" the external charge distribution by their electromagnetic field body and field body also carries this distribution since CP_2 extremals do not carry it. One could also defend this interpretation by saying that electrons is operationally only what can be observed about it through various interactions and therefore Compton length (various Compton length like parameters) must be assigned with its field body (bodies).

Also maximal quantum criticality implies that darkness is restricted to field bodies but does not exclude the possibility that elementary particle like structures can possess non-minimal quantum criticality and thus possess multi-sheeted character.

4.3.2 Option I: nuclei are electromagnetically dark

The general vision about nuclear dark matter suggests that the system consists of super-nuclei analogous to ordinary nuclei such that electrons are ordinary and do not screen the Coulomb potentials of atomic nuclei.

The simplest possibility is that the electromagnetic field bodies of nuclei or quarks become dark implying de-localization of nuclear charge. The valence electrons would form a kind of mini-conductor with electrons de-localized in the volume of the cluster. The electronic analog of the nuclear shell model predicts that full electron shells define stable configurations analogous to magic nuclei. The model explains the numbers of atoms in chemically inert Al and Ca clusters and generalizes the notion of valence to the level of cluster so that the cluster would behave like single super-atom.

The electromagnetic $k = 113$ space-time sheets (em field bodies) of quarks could have scaled up size $\sqrt{r}L(113) = L(113 + k_d) = 2^{k_d/2} \times 2 \times 10^{-14}$ m. One would have atomic size scale .8 Angstroms for $r = 2^{k_d}$, $k_d = 24$- an option already introduced. A suggestive interpretation is that the electric charge of nuclei or valence quarks assignable to their field bodies is de-localized quantum mechanically to atomic length scale. Electrons would in a good approximation experience quantum mechanically the nuclear charges as a constant background, jellium, whose effect is indeed modellable using harmonic oscillator potential.

One can test the proposed criterion for the phase transition to darkness. The unscreened electromagnetic interaction energy between a block of partially ionized nuclei with a net em charge Z with Z electrons would define the relevant parameter as $r \equiv Z^2\alpha$. For the total charge $Z \geq 12$ the condition $r \geq 1$ is satisfied. For a full shell with 8 electrons this condition is not satisfied.

4.3.3 Option II: Electrons are electro-magnetically dark

Since the energy spectrum of harmonic oscillator potential is invariant under the scaling of $\hbar$ accompanied by the opposite scaling of the oscillator frequency ω, one must consider also the em bodies of electrons are in large $\hbar$ phase (one can of course ask whether they could be observed in this phase!). The rule would be that the size of the bound states is larger than the scaled up electron Compton length.

The Compton wavelength of electrons would be scaled up by a factor r where r is product of different Fermat primes and power of 2 for ruler and compass hypothesis. For Mersenne hypothesis one would have $r = 2^{k_d}$. For $k_d = 24$ the effective p-adic scale of electron would be to about $L(151) = 10$ nm. The atomic cluster of this size would contain roughly $10^6 \times (a_0/a)^3$ atoms where a is atomic volume and $a_0 = 1$ Angstrom is the natural unit.

The shell model of nucleus is in TGD framework a phenomenological description justified by nuclear string model with string tension responsible for the oscillator potential. This leads to ask whether the electrons of jellium actually form analogs of nuclear strings with electrons connected by color bonds.

5 Has Dark Matter Been Observed?

In this section two examples about anomalies perhaps having interpretation in terms of quantized Planck constant are discussed. The first anomaly belongs to the realm of particle physics and hence does not quite fit the title of the chapter. Second anomaly relates to nuclear physics.

5.1 Optical Rotation Of A Laser Beam In A Magnetic Field

The group of G. Cantatore has reported an optical rotation of a laser beam in a magnetic field [D16]. The experimental arrangement involves a magnetic field of strength $B = 5$ Tesla. Laser beam travels 22000 times forth and back in a direction orthogonal to the magnetic field travelling 1 m

during each pass through the magnet. The wavelength of the laser light is 1064 nm (the energy is 1.1654 eV). A rotation of $(3.9 \pm .5) \times 10^{-12}$ rad/pass is observed.

Faraday effect [D4] is optical rotation which occurs when photon beam propagates in a direction parallel to the magnetic field and requires parity breaking guaranteeing that the velocities of propagation for two circular polariations are different. Now however the laser beam is orthogonal to the magnetic field so that Faraday effect cannot be in question.

The proposed interpretation for the rotation would be that the component of photon having polarization parallel to the magnetic field mixes with QCD axion, one of the many candidates for dark matter. The mass of the axion would be about 1 meV. Mixing would imply a reduction of the corresponding polarization component and thus in the generic case induce a rotation of the polarization direction. Note that the laser beam could partially transform to axions, travel through a non-transparent wall, and appear again as ordinary photons.

The disturbing finding is that the rate for the rotation is by a factor 2.8×10^4 higher than predicted. This would have catastrophic astrophysical implications since stars would rapidly lose their energy via axion radiation.

What explanations one could imagine for the observations in TGD framework if one accepts the hierarchy of Planck constants?

1. The simplest model that I have been able to imagine does not assume axion like states. The optical rotation would be due to the leakage of the laser photons to dark pages of the Big Book at the ends of the magnet where the space-time sheet carrying the magnetic field becomes locally a vacuum extremal. This explanation would not mean direct seeing of dark matter but the observation of a transformation of ordinary matter to dark matter. Quite generally, this experimental approach might be much better strategy to the experimental proof of the existence of the dark matter than the usual approaches and is especially attractive in living matter.

2. TGD could also provide a justification for the axion based explanation of the optical rotation involving parity breaking. TGD predicts the existence of a hierarchy of QCD type physics based on the predicted hierarchy of scaled up variants of quarks and also those of color excited leptons. The fact that these states are not seen in the decay widths of intermediate gauge bosons can be understood if the particles in question are dark matter with non-standard value of Planck constant and hence residing at different page of the book like structure formed by the imbedding space. I have discussed in detail the general model in the case of lepto-hadrons consisting of colored excitation of ordinary lepton and explaining quite an impressive bundle of anomalies [K36]. Since lepto-pion has quantum numbers of axion and similar couplings, it is natural to propose that the claimed axion like particle -if it indeed exists- is a pion like state consisting either exotic light quarks or leptons.

   The dark variants of hadron physics are suggestive in living matter. By p-adic length scale hypothesis one expects that the mass of axion-like state identifiable as a scaled variant of pion would relate by a power of $\sqrt{2}$ to pion mass. For 1 meV axion like particle, call it A, the mass ratio is $m(\pi)/m(A) = 2^{37} \times 1.004$ and indeed very near to a power of 2.

3. Rather interestingly, years later emerged evidence for an axion like particle interpreted as dark matter and having mass $m(A) = .11$ meV. The decays of this particle in the electric field of Josephson junction generate photon absorbed by Cooper pair are claimed to induce resonantly an anomalous Josephson current [D14] (`http://tinyurl.com/yck3qeyb`). If there exists several dark copies of hadron physics, it would not be surprising if the pions of these copies would behave like axions. Interpretation as scaled variant of electro-pion however yields a mass ratio nearer to a power of two: it consists of electron and positron and has mass $m(\pi_L) \simeq 2m_e$ given $m(\pi_L)(m(A) \simeq 1.08$. For ordinary pion the ratio is $m(\pi)(m(A) \simeq 1.14$.

4. The TGD inspired model would differ from the above model only in that the leakage to the dark sector would take place by a transformation of the laser photon to a pionlike state so that no parity breaking would take place. But the basic point is that vacuum extremals through which the leakage can occur, break the parity strongly by the presence of classical Z^0 fields. The idea about leakage together with the non-constancy of pion-type field appearing in the coupling to the instanton density imply that that the space-time sheet representing the

magnetic field is vacuum extremal -at least in some regions- and this assumption looks unnecessarily strong. Also detailed assumptions about the dependence of the basic parameters appearing in PCAC hypothesis must be made.

What raised the hopes was the intriguing observation that the ratio of laser photon frequency to the cyclotron frequency of electron in the magnetic field considered equals to $r = 2^{11}$: this put bells ringing in the p-adically tuned mind and inspired the question whether one could have $\hbar/\hbar_0 = 2^{11}$. It must be however emphasized that this assumption about the values of $\hbar$ might be too restrictive. The assumption of cyclotron condensate of electron pairs at dark space-time sheet must be however justified and one must answer at least the question why it is needed. A possible answer would be that the leakage occurs via Bose-Einstein condensation to a coherent state of cyclotron photons. But this would mean return to the original model where laser photons leak! Obviously the model becomes too complicated for Occam and therefore I have dropped out the model.

The simplest model should start just from the finding that the linear polarization parallel to the magnetic field seems to leak with a certain rate as it traverses the magnet. The leakage of laser photons to a dark matter space-time sheet is what comes mind first in TGD context. A killer test for this explanation is to use polarization parallel to the magnetic field: in this case no optical rotation should take place.

1. The leakage should take place along the intersection of the pages of the Big Book which correspond to geodesically trivial geodesic sphere of CP_2 so that induced Kähler field vanishes and vacuum extremals or nearly vacuum extremals are in question. Leakage could occur within magnet or the ends of the magnet could involve this kind of critical membrane like region and as the photon passes through them the leakage could occur.

2. Since parity breaking takes place, the instanton density for the electromagnetic field provides a natural description of the situation. The interaction term is obtained by replacing either E in $E \cdot B$ with its quantized counterpart describing laser photons. This gives a linear coupling to photon oscillator operators completely analogous to a coupling to an external current and one can calculate the leakage rate using the standard rules.

3. The interaction term is total divergence and reduces to a 3-D Chern-Simons type term associated with the boundaries of the membrane like region or magnet in the general case and the leakage can be said to occur at the ends of the magnet for non-vacuum exremals.

One can ask whether one should use the instanton density of Kähler field rather than that of em field in the model. In this case Kähler gauge potential would couple the quantized em field via U(1) part of em charge. One would not have gauge invariance since for the induced Kähler field gauge degeneracy is replaced with spin glass degeneracy and gauge transformations of the vacuum extremals induced by symplectic transformations of CP_2 deform the space-time surface. In this case E in $E \cdot A$ would be replaced with the radiation field at the ends of the magnet. In order to have a non-vanishing leakage the instanton density within magnet must be non-vanishing meaning that CP_2 projection of the magnet's space-time sheet must be 4-D at least somewhere. For the first option it can be 2-D.

The coefficient K of the instanton term defining the action should depend on the value of Planck constant. $1/e^2$ proportionality of the ordinary Maxwell action means that the coefficient of the instanton term could be propertional to $\hbar$. The most general dependence $K = k(e^2\hbar/4\pi)/e^2 \equiv f(\alpha_{em}r)/e^2$, $r = \hbar/\hbar_0$. Since non-perturbative effect is in question $k((\alpha_{em}r) \propto 1/(\alpha_{em}r)$ is suggestive and guarantees that the leakage probability becomes small for large values of Planck constant.

This option will not be discussed further but it might have also relevance to the parity breaking in biology. In fact, I have proposed that the realization of genetic code based on nuclelotide dependent optical rotation of polarization of photons proposed by Gariaev [I3] could be based on Faraday effect or its analogy [K35].

One can consider also a generalization of this model by assuming that photon transforms to dark pion-like state in the leakage. In this case the action does not however reduce to a total divergence and the condition that the entire magnet corresponds to vacuum extremal seems to be unrealistic.

5.2 Do Nuclear Reaction Rates Depend On Environment?

Claus Rolfs and his group have found experimental evidence for the dependence of the rates of nuclear reactions on the condensed matter environment [C13]. For instance, the rates for the reactions ^{50}V(p, n)^{50}Cr and ^{176}Lu(p, n) are fastest in conductors. The model explaining the findings has been tested for elements covering a large portion of the periodic table.

5.2.1 Debye screening of nuclear charge by electrons as an explanation for the findings?

The proposed theoretical explanation [C13] is that conduction electrons screen the nuclear charge or equivalently that incoming proton gets additional acceleration in the attractive Coulomb field of electrons so that the effective collision energy increases so that reaction rates below Coulomb wall increase since the thickness of the Coulomb barrier is reduced.

The resulting Debye radius

$$R_D = 69\sqrt{\frac{T}{n_{eff}\rho_a}} \ , \tag{5.1}$$

where ρ_a is the density of atoms per cubic meter and T is measured in Kelvins. R_D is of order.01 Angstroms for $T = 373$ K for $n_{eff} = 1$, $a = 10^{-10}$ m. The theoretical model [C4, C22] predicts that the cross section below Coulomb barrier for $X(p, n)$ collisions is enhanced by the factor

$$f(E) = \frac{E}{E + U_e} exp(\frac{\pi\eta U_e}{E}) \ . \tag{5.2}$$

E is center of mass energy and η so called Sommerfeld parameter and

$$U_e \equiv U_D = 2.09 \times 10^{-11}(Z(Z+1))^{1/2} \times (\frac{n_{eff}\rho_a}{T})^{1/2} \ eV \tag{5.3}$$

is the screening energy defined as the Coulomb interaction energy of electron cloud responsible for Debye screening and projectile nucleus. The idea is that at R_D nuclear charge is nearly completely screened so that the energy of projectile is $E + U_e$ at this radius which means effectively higher collision energy.

The experimental findings from the study of 52 metals support the expression for the screening factor across the periodic table.

1. The linear dependence of U_e on Z and $T^{-1/2}$ dependence on temperature conforms with the prediction. Also the predicted dependence on energy has been tested [C13].

2. The value of the effective number n_{eff} of screening electrons deduced from the experimental data is consistent with $n_{eff}(Hall)$ deduced from quantum Hall effect.

The model suggests that also the decay rates of nuclei, say beta and alpha decay rates, could be affected by electron screening. There is already preliminary evidence for the reduction of beta decay rate of ^{22}Na β decay rate in Pd [C12], metal which is utilized also in cold fusion experiments. This might have quite far reaching technological implications. For instance, the artificial reduction of half-lives of the radioactive nuclei could allow an effective treatment of radio-active wastes. An interesting question is whether screening effect could explain cold fusion [C7] and sono-fusion [C14]: I have proposed a different model for cold fusion based on large $\hbar$ in [K32].

5.2.2 Could quantization of Planck constant explain why Debye model works?

The basic objection against the Debye model is that the thermodynamical treatment of electrons as classical particles below the atomic radius is in conflict with the basic assumptions of atomic physics. On the other hand, it is not trivial to invent models reproducing the predictions of the

Debye model so that it makes sense to ask whether the quantization of Planck constant predicted by TGD could explain why Debye model works.

TGD predicts that Planck constant is quantized in integer multiples: $\hbar = n\hbar_0$, where $\hbar_0$ is the minimal value of Planck constant identified tentatively as the ordinary Planck constant. The preferred values for the scaling factors n of $\hbar$ correspond to n-polygons constructible using ruler and compass. The values of n in question are given by $n_F = 2^k \prod_i F_{s_i}$, where the Fermat primes $F_s = 2^{2^s}+1$ appearing in the product are distinct. The lowest Fermat primes are $3, 5, 17, 257, 2^{16}+1$. In the model of living matter the especially favored values of $\hbar$ come as powers 2^{k11} [K8, K9].

It is not quite obvious that ordinary nuclear physics and atomic physics should correspond to the minimum value $\hbar_0$ of Planck constant. The predictions for the favored values of n are not affected if one has $\hbar(stand) = 2^k\hbar_0$, $k \geq 0$. The non-perturbative character of strong force suggests that the Planck constant for nuclear physics is not actually the minimal one [K32]. As a matter fact, TGD based model for nucleus implies that its "color magnetic body" has size of order electron Compton length. Also valence quarks inside hadrons have been proposed to correspond to non-minimal value of Planck constant since color confinement is definitely a non-perturbative effect. Since the lowest order classical predictions for the scattering cross sections in perturbative phase do not depend on the value of the Planck constant one can consider the testing of this issue is not trivial in the case of nuclear physics where perturbative approach does not really work.

Suppose that one has $n = n_0 = 2^{k_0} > 1$ for nuclei so that their quantum sizes are of order electron Compton length or perhaps even larger. One could even consider the possibility that both nuclei and atomic electrons correspond to $n = n_0$, and that conduction electrons can make a transition to a state with $n_1 < n_0$. This transition could actually explain how the electron conductivity is reduced to a finite value. In this state electrons would have Compton length scaled down by a factor n_0/n_1.

For instance, if one has $n_0 = 2^{11k_0}$ as suggested by the model for quantum biology [K9] and by the TGD based explanation of the claimed detection of dark matter [D16], the Compton length $L_e = 2.4 \times 10^{-12}$ m for electron would reduce in the transition $k_0 \to k_0 - 1$ to $L_e = 2^{-11}L_e \simeq 1.17$ fm, which is rather near to the proton Compton length since one has $m_p/m_e \simeq .94 \times 2^{11}$. It is not too difficult to believe that electrons in this state could behave like classical particles with respect to their interaction with nuclei and atoms so that Debye model would work.

The basic objection against this model is that anyonic atoms should allow more states that ordinary atoms since very space-time sheet can carry up to n electrons with identical quantum numbers in conventional sense. This should have been seen.

5.2.3 Electron screening and Trojan horse mechanism

An alternative mechanism is based on Trojan horse mechanism suggested as a basic mechanism of cold fusion [K32]. The idea is that projectile nucleus enters the region of the target nucleus along a larger space-time sheet and in this manner avoids the Coulomb wall. The nuclear reaction itself occurs conventionally. In conductors the space-time sheet of conduction electrons is a natural candidate for the larger space-time sheet.

At conduction electron space-time sheet there is a constant charged density consisting of n_{eff} electrons in the atomic volume $V = 1/n_a$. This creates harmonic oscillator potential in which incoming proton accelerates towards origin. The interaction energy at radius r is given by

$$V(r) = \alpha n_{eff} \frac{r^2}{2a^3} , \tag{5.4}$$

where a is atomic radius.

The proton ends up to this space-time sheet by a thermal kick compensating the harmonic oscillator energy. This occurs below with a high probability below radius R for which the thermal energy $E = T/2$ of electron corresponds to the energy in the harmonic oscillator potential. This gives the condition

$$R = \sqrt{\frac{Ta}{n_{eff}\alpha}}a . \tag{5.5}$$

This condition is exactly of the same form as the condition given by Debye model for electron screening but has a completely different physical interpretation.

Since the proton need not travel through the nuclear Coulomb potential, it effectively gains the energy

$$E_e = Z\frac{\alpha}{R} = \frac{Z\alpha^{3/2}}{a}\sqrt{\frac{n_{eff}}{Ta}} \quad . \tag{5.6}$$

which would be otherwise lost in the repulsive nuclear Coulomb potential. Note that the contribution of the thermal energy to E_e is neglected. The dependence on the parameters involved is exactly the same as in the case of Debye model. For $T = 373$ K in the ^{176}Lu experiment and $n_{eff}(Lu) = 2.2 \pm 1.2$, and $a = a_0 = .52 \times 10^{-10}$ m (Bohr radius of hydrogen as estimate for atomic radius), one has $E_e = 28.0$ keV to be compared with $U_e = 21 \pm 6$ keV of [C13] ($a = 10^{-10}$m corresponds to 1.24×10^4 eV and 1 K to 10^{-4} eV). A slightly larger atomic radius allows to achieve consistency. The value of $\hbar$ does not play any role in this model since the considerations are purely classical.

An interesting question is what the model says about the decay rates of nuclei in conductors. For instance, if the proton from the decaying nucleus can enter directly to the space-time sheet of the conduction electrons, the Coulomb wall corresponds to the Coulomb interaction energy of proton with conduction electrons at atomic radius and is equal to $\alpha n_{eff}/a$ so that the decay rate should be enhanced.

5.3 Refraction Of Gamma Rays From Silicon Prism?

The following considerations were inspired by to a popular article [D12] (`http://tinyurl.com/ydautan4`) telling about refraction of gamma rays from silicon prisms. This should not be possible and since I love anomalies I got interested. Below I discuss the discovery from the point of standard physics and TGD point of view.

5.3.1 What happens in refraction?

Absorption, reflection, and refraction are basic phenomena of geometric optics (see `http://tinyurl.com/y7bqfu8m`) [D5] describing the propagation of light in terms of light rays and neglecting interference and diffraction making it possible for light to "go around the corner". The properties of medium are described in terms of refraction index n which in general is a complex quantity. The real part of n gives the phase velocity of light in medium using vacuum velocity c as unit, which - contrary to a rather common misconception - can be also larger than c as a phase velocity which cannot be assigned to energy transfer. The imaginary part characterizes absorption. n depends in general on frequency of the incoming light and the resonant interactions of light with the atoms of medium make themselves manifest in the frequency dependence of n - in particular in absorption described by the imaginary part of n.

What happens in the boundary of two media - reflection or refraction - is characterized the refraction index boundary conditions for radiation fields at the boundary, which are essentially Maxwell's equations at the discontinuity. Snell's law tells what happens to the direction of the beam and states essentially that only the momentum component of incoming photon normal to the boundary changes in these processes since only the translational symmetry in normal direction is changed.

5.3.2 How refractive index is determined?

What determines the index of refraction (see `http://tinyurl.com/qcdk687`) [D6] ? To build a microscopic theory for n one must model what happens for the incoming beam of light in medium. One must model the scattering of light from the atoms of the medium.

In the case of condensed matter X ray diffraction is excellent example about this kind of theory. In this case the lattice structure of the condensed matter system makes the situation simple. For infinitely large medium and for an infinitely wide incoming beam the scattering amplitude is just the Fourier transform of the density of atoms for the change of the wave vector (or equivalently

momentum) of photon, which must be a vector in the resiprocal lattice of the crystal lattice. Therefore the beam is split into beams in precisely defined directions. The diffracted beam has a sharp maximum in forward direction and the amplitude in this direction is essentially the number of atoms.

In less regular situation such as for water or bio-matter for which regular lattice structure typically exists only locally the peaking to forward direction, is even more pronounced, and in the first approximation the beam travels in the direction that it has after entering to the system and only the phase velocity is changed and attenuation takes place. Diffraction patterns are however present also now and allow to deduce information about the structure of medium in short length scales. For instance, Delbrueck diffraction from biological matter allowed to deduce structural information about DNA and deduce its structure.

This description contains an important implicit assumption. The width and length of the incoming photon beam must be so large that the number of atoms inside it is large enough. If this condition is not satisfied, the large scale interference effects crucial for diffraction do not take place. For very narrow beams the situation approaches to a scattering from single atom and one expects that the beam is gradually widened but that it does not make sense to speak about refraction index and that the application of Snell's law does not make sense. Incoming photons see individual atoms rather than the lattice of atoms. For this reason the prevailing wisdom has been that it does not make sense to speak about bending of gamma rays from solid state. A gamma ray photon with energy of one MeV corresponds to a wavelength λ of about 10^{-12} meters which is of same order as electron Compton length. One expects that the width and length of gamma ray beam is measured using λ as a natural unit. Even width of 100 wavelengths corresponds to 1 Angstrom which corresponds to the size scale of single atom.

5.3.3 Surprise

The real surprise was that gamma rays bend in prisms made from silicon! The discovery (see `http://tinyurl.com/ydautan4`) was made by a group of scientists working in Ludwig-Maximilians-Universität in Munich [D12, D13, D18]. The group was led by Dietrich Habs. The gamma ray energies where in the range.18-2 MeV. The bending known as refraction was very small using every day standards. The value of the refractive index which gives the ratio c/v for light velocity c to the light velocity v in silicon is $1 + 10^{-9}$ as one learns from another popular article (see `http://tinyurl.com/p4zy9a6`) [D13]. When compared to the predictions of the existing theory, the bending was however anomalously large. By the previous argument it should not be even possible to talk about bending.

Dietrich Habs suggests that so called Delbrueck scattering of gamma rays from virtual electron positron pairs created in the electric fields of atoms could explain (see `http://tinyurl.com/ydautan4`) the result. This scattering would be diffraction (scattering almost totally in forward direction as for light coming through a hole). This cannot however give rise to an effective scattering from a many-atom system unless the gamma ray beam is effectively or in real sense scaled up. The scattering would be still from single atom or even part of single atom. One could of course imagine that atoms themselves have hidden structure analogous to lattice structure but why virtual electron pairs could give rise to it?

In the following I discuss two TGD inspired proposals for how the diffraction that should not occur could occur after all?

5.3.4 Could gamma rays scatter from quarks?

There is another strange anomaly that I discussed for a couple of years ago christened as the incredibly shrinking proton (see `http://tinyurl.com/y9aklsbk`) [K22]. It was found that protons charge distribution deviates slightly from the expected one. The TGD inspired explanation was based on the observation that quarks in proton are rather light having masses of 5 and 20 MeV. These correspond to gamma ray energies. Therefore the Compton wave lengths of quarks are also rather long, much longer than the Compton length of proton itself! Parts would be larger than the whole! The explanation for this quantum mystical fact would be that the Compton length corresponds to length scale assignable to color magnetic body of quark. Could it be that the scattering gamma rays see the magnetic bodies of $3 \times 14 = 42$ valence quarks of 14 nucleons of

Si nucleus. The regular structure of atomic nucleus as composite of quark magnetic would induce the diffractive pattern. If so, we could do some day nuclear physics and perhaps even study the structure of proton by studying diffraction patterns of gamma rays on nuclei!

5.3.5 Could part of gamma beam transform to large $\hbar$ gamma rays?

Also the hierarchy of Planck constants (see `http://tinyurl.com/y7c8e6x8`) [K12] comes in mind. Scaling of $\hbar$ for a fixed photon energy scales up the wavelength of gamma ray. Could some fraction of incoming gamma rays suffer a phase transition increasing their Planck constant? The scaling of Planck constant make gamma rays to behave like photons with scaled up wavelength. Also the width of the beam would be zoomed up. As a result the incoming gamma ray beam would see a group of atoms instead of single atom and for a large enough value of Planck constant one could speak of diffraction giving rise to refraction.

For years ago I considered half jokingly the possibility that hierarchy of Planck constants could imply quantum effects in much longer scales than usually [K12]. Diffraction would be a typical quantum effect involving interference. Perhaps even the spots seen sometimes in ordinary camera lense could be analogous to diffractive spots generated by diffraction of large $\hbar$ visible photons through a hole (they should usually appear in the scale of visible wavelength about few microns [K10]. Take this as a joke!

I also proposed that strong classical em fields provide the environment inducing increase of Planck constant at some space-time sheets. The proposal was that Mother Nature is theoretician friendly [K12]. As perturbation expansion in powers of $1/\hbar$ fails, Mama Nature scales up $\hbar$ to make the life of her theorizing children easier, one might say. Strong electric and magnetic fields of atomic nuclei believed by Habs to be behind the diffraction might provide the manner to generate large Planck constant phases and dark matter.

6 Water And New Physics

In this section the previous ideas are applied in an attempt to understand the very special properties of water.

6.1 The 41 Anomalies Of Water

The following list of 41 anomalies of water taken from [D24] should convince the reader about the very special nature of water. The detailed descriptions of the anomalies can be found in [D24]. As a matter fact, the number of anomalies had grown to 63 when I made my last visit to the homepage of Chaplin.

The many anomalies of water need not be all due to the presence of the dark matter. As suggested already fifteen years ago, p-adic length scale hierarchy forces to replace ordinary thermodynamics with a p-adic fractal hierarchy of thermodynamics and this means that one must speak about thermodynamics in a given length scale rather than mere thermodynamics of continuous matter.

Instead of listing just the anomalies I suggest also a possible interpretation based on the assumption that some fraction of protons (and perhaps also OH^- ions) is dark. This hypothesis is motivated by the scattering data suggesting that $H_{1.5}O$ is the proper chemical formula for water in atto-second time scale and explained by assuming that about 1/4 of protons are dark in the experimental situation. It is natural to assume that the increase of temperature or pressure reduces the dark portion. Unless the establishment of equilibrium ratio for dark and ordinary phase is very fast process, water can be regarded as a two-phase system mathematically. A continuous spectrum of metastable forms of water and ice distinguished by the ratio of the densities of ordinary and dark phase is expected. Complex phase diagrams is also a natural outcome.

Dark portion is expected to induce long range correlations affecting melting/boiling/critical points, viscosity, and heats of vaporization and fusion. Anomalous behaviors under the changes of temperature and pressure and anomalies in compressibility and thermal expansivity are expected. Specific heats and transport properties are affected by the presence of dark degrees of freedom, and the coupling of electromagnetic radiation to dark degrees of freedom influences the di-electric properties of water.

In order to systematisize the discussion I have classified the anomalous to different groups.

1. Anomalies suggesting the presence of dark phase inducing long range correlations.

   (a) Water has unusually high melting point.

   (b) Water has unusually high boiling point.

   (c) Water has unusually high critical point.

   (d) Water has unusually high surface tension and can bounce.

   (e) Water has unusually high viscosity.

   (f) Water has unusually high heat of vaporization.

   Comment: The presence of dark portion implies long range correlations and they could help to restore solid/liquid phase, raise the the critical point, increase surface tension, increase viscosity and require more energy to achieve vaporization. The ability to bounce would suggest that dark portion of water -at least near the surface- is in solid phase. Dark water is in rubber-like phase also in the interior below a length scale defined by the length of dark flux tubes.

2. Anomalies related to the effect of temperature increase.

   (a) Water shrinks on melting.

   (b) Water has a high density that increases on heating (up to 3.984°C).

   (c) The number of nearest neighbors increases on melting.

   (d) The number of nearest neighbors increases with temperature.

   (e) Water shows an unusually large viscosity increase but diffusion decrease as the temperature is lowered.

   (f) At low temperatures, the self-diffusion of water increases as the density and pressure increase.

   (g) Water has a low coefficient of expansion (thermal expansivity).

   (h) Water's thermal expansivity reduces increasingly (becoming negative) at low temperatures.

   Comment: The increase of temperature induces shrinking of the flux tubes connecting water molecules in the phase transition reducing Planck constant and brings the molecules closer to each other. This could explain shrinking on melting, the increase of the density in some temperature range above which the normal thermal expansion would win the shrinking tendency, the increase of nearest neighbors on melting and with the increase of temperature. Concerning the shrinking on melting one can however argue that the regular lattice like structure of ice is not that with minimum volume per molecule so that no new physics would be needed unless it is needed to explain why the volume per molecule is not minimum.

   The unusually large viscosity increase with reduce temperature would be due to the increase of the large $\hbar$ portion inducing long range correlations. If the diffusion takes place only in the normal phase the anomalous reduction of diffusion could be due to the reduction of the density of the normal phase. Similar explanation applies to the behavior of self-diffusion.

   The low value of coefficient of thermal expansion could be understood in terms of the phase transitions reducing the flux tube lengths and bringing the molecules near to each other and thus reducing the normal thermal expansion. At low enough temperatures the expansivity would become negative since this effect would overcome the normal thermal expansion.

3. Anomalies related to the effects of pressure.

   (a) Pressure reduces its melting point (13.35 MPa about 133.5 times the standard atmospheric pressure) gives a melting point of -1°C)

   (b) Pressure reduces the temperature of maximum density.

(c) D_2O and T_2O differ from H_2O in their physical properties much more than might be expected from their increased mass; e.g. they have increasing temperatures of maximum density (11.185°C and 13.4°C respectively).

(d) Water's viscosity decreases with pressure (at temperatures below 33°C).

Comment: The reduction of melting point, temperature of maximum density, and viscosity with pressure could be due to the reduction of the dark portion as pressure increases. Pressure would induce the phase transition reducing the value of Planck constant for the flux tubes connecting water molecules. That the situation is different for D_2O and T_2O could be understood if dark D and T are absent. The question is what happens in the transition to solid phase. The reduction of the density would conform with the idea that the portion of dark phase increases. The reduction of viscosity with pressure would would follow from the reduction of dark phase causing long range correlations.

4. Anomalies related to compressibility.

   (a) Water has unusually low compressibility.

   (b) The compressibility drops as temperature increases down to a minimum at about 46.5°C. Below this temperature, water is easier to compress as the temperature is lowered.

   Comment: The anomalously high compressibility below 46.5°C could be understood if only the standard phase responds to pressure appreciably. In this case the effective density is smaller than the net density and make it easier to compress the water as the temperature is lowered. The increase of temperature would increase the effective density as dark matter is transformed to ordinary one and reduce the compressibility. Above 46.5°C the effect of dark matter would be overcome by the increase of compressibility due to the increase of temperature.

   (c) The speed of sound increases with temperature (up to a maximum at 73°C).

   Comment: The speed of sound is given by the expression

$$c^2 = \frac{\partial p}{\partial \rho} \ .$$

   Pressure p is essentially the density of thermal energy associate with the ordinary matter. When the fraction of ordinary matter increases the pressure effectively increases and this leads to the increase of c.

   (d) Under high pressure water molecules move further away from each other with increasing pressure.

   Comment: The behavior under increasing high pressure is in conflict with the hypothesis that pressure tends to reduce the portion of dark phase. The question is why the increase of pressure at high enough pressures would induce phase transition increasing the value of Planck constant for the flux tubes connecting the molecules? If the dark matter does not respond to pressure appreciably, the increase of the portion of dark matter might allow the minimization of energy. Does this mean that the work done by the high enough pressure to reduce the volume is larger than the energy needed to induce the tunnelling to the dark phase?

5. Anomalies related to the heat capacity.

   (a) Water has over twice the specific heat capacity of ice or steam.

   (b) The specific heat capacity (C_P and C_V) is unusually high.

   (c) Specific heat capacity C_P has a minimum.

Comment: The anomalously high heat capacity of water could be understood in terms of dark non-translational degrees of freedom even if the dark phase is rubber-like below the length scale of the dark flux tubes. The energy pumped to the system would go to these degrees of freedom. The small heat capacity of solid phase would suggest that the freezing means also freezing of these degrees of freedom meaning the reduction of the contribution to heat capacity.

6. Anomalies related to phase transitions

   (a) Supercooled water has two phases and a second critical point at about -91°C.

   (b) Liquid water may be supercooled, in tiny droplets, down to about -70°C. It may also be produced from glassy amorphous ice between -123°C and - 149°C and may coexist with cubic ice up to -63°C.

   (c) Solid water exists in a wider variety of stable (and metastable) crystal and amorphous structures than other materials.

   (d) The heat of fusion of water with temperature exhibits a maximum at -17°C.

   Comment: The presence of both dark and ordinary phase with varying ratio of densities could help to understand the richness of the structures below freezing point. For instance, one can imagine that either the ordinary or dark phase is super-cooled and the other freezes.

7. Anomalies of solutions of water.

   (a) Solutes have varying effects on properties such as density and viscosity.

   (b) None of its solutions even approach thermodynamic ideality; even D_2O in H_2O is not ideal.

   (c) The solubilities of non-polar gases in water decrease with temperature to a minimum and then rise.

   Comment: The different interactions of solutes with the dark phase could explain these findings. For instance, the probability that the presence of solute induces a phase transition reducing the portion of the dark phase could depend on solute. The decrease of the solubilities of non-polar gases in water with temperature could be due to the fact that the solubility is at low temperatures basically due to the presence of the dark phase. At higher temperatures higher thermal energies of the solute molecules would increase the solubility.

8. Anomalies in transport properties.

   (a) NMR spin-lattice relaxation time is very short at low temperatures.

   Comment: The transfer of magnetic energy to the dark degrees of freedom could dominate the relaxation process. If synchrotron Bose-Einstein condensates are present in dark degrees of freedom this might make sense.

   (b) Hot water may freeze faster than cold water; the Mpemba effect [D8]. For instance, water sample in 100 C freezes faster than that in 35 C.

   Comment: This effect seems to be in conflict with thermodynamics and remains poorly understood. The possibility of having continuum of metastable two-phase systems suggests a possible solution to the mystery. The freezing of the dark portion of water should occur slower than the freezing of the ordinary portion since the heat transfer rate is expected to be lower for a larger value of Planck constant. The very naive just-for-definiteness estimate is that the transfer rate for energy to the cold system is inversely proportional to $1/\hbar$. If the formation of dark phase is a slow process as compared to the transfer of energy to the cold phase, the freezing of hot water would lead to a metastable ice consisting mostly of ordinary water molecules and takes place faster than the freezing of cold water already containing the slowly freezing dark portion.

   (c) Proton and hydroxide ion mobilities are anomalously fast in an electric field.

   Comment: Mobility is of form $a\tau$, where a the acceleration a in the electric field times the characteristic time τ for motion without collisions. If part of protons move along dark flux tubes this time is longer. The high mobility of OH_- ions would suggest that also these can be in dark phase.

   (d) The electrical conductivity of water rises to a maximum at about 230°C and then falls.

   Comment: Electrical conductivity is closely related to mobility so that the same argument applies.

(e) The thermal conductivity of water is high and rises to a maximum at about 130°C.

Comment: The anomalously high thermal conductivity could be due to the motion of heat carriers along dark flux tubes with low dissipation.

(f) Warm water vibrates longer than cold water.

Comment: This could be due to the faster transfer of vibrational energy to the dark vibrational of magnetic degrees of freedom. If the number of these degrees of freedom is higher than the number of ordinary degrees of freedom, one can understand also the anomalously high heat capacity. Vibration could continue in dark degrees of freedom in which case the effect would be apparent. If its only the ordinary water which vibrates in the original situation then equipartition of energy with dark degrees of freedom implies apparent dissipation.

9. Anomalous electromagnetic properties of water.

(a) X-ray diffraction shows an unusually detailed structure.

Comment: This would not be surprising if two phases with possibly varying ratio are present. For instance, the different X-ray diffraction patterns for water obtained by a rapid freezing from high and low temperatures could serve as a test for the proposed explanation of Mpemba effect.

(b) The dielectric constant is high and behaves anomalously with temperature.

Comment: This could relate to the interaction of photons with dark portion of water. Dielectric constant characterizes the coupling of radiation to oscillatory degrees of freedom and is sum of terms proportional to $1/(\omega^2 - \omega_i^2)$, where ω_i is resonance frequency. If the resonance frequencies ω_i scale as $1/\hbar$, dark portion gives a larger contribution at frequencies $\omega < \omega_i$. In particular the static dielectric constant increases.

(c) The refractive index of water has a maximum value at just below 0°C.

Comment: It is not quite clear whether this maximum corresponds to room pressure or appears quite generally. Let us assume the first option. In any case the dependence of the freezing temperature on pressure is very weak. The maximal interaction with the dark portion of water at freezing point combined with the above argument would predict that refractive index increases down to the freezing point. The reduction of the density at freezing point would reduce the refractive index since dynamic susceptibility is proportional to the density of atom so that a maximum would be the outcome.

These examples might serve as a motivation for an attempt to build a more detailed model for the dark portion of water. The model to be discussed was one of the first attempts to understand the implications of the idea about hierarchy of Planck constants. Since five years have passed is badly in need of updating.

6.2 The Model

Networks of directed hydrogen bonds $H - O - H \cdots OH_2$ with positively charged H acting as a binding unit between negatively charged O (donor) and OH_2 (acceptor) bonds explaining clustering of water molecules can be used to explain qualitatively many of the anomalies at least qualitatively [D24].

The anomaly giving evidence for anomalous nuclear physics is that the physical properties D_2O and T_2O differ much more from H_2O than one might expect on basis of increased masses of water molecules. This suggests that dark protons could be responsible for the anomalies. That heavy water in large concentrations acts as a poison is consistent with the view that the macroscopic quantum phase of dark protons is responsible for the special biological role of water.

6.2.1 What proton darkness could mean?

In the experimental situation one fourth of protons of water are not seen in neither electron nor neutron scattering in atto-second time scale which translates 3 Angstrom wavelength scale suggesting that in both cases diffraction scattering is in question. This of course does not mean

that the fraction of dark protons is always 1/4 and it is indeed natural to assume that it is reduced at higher temperatures. Both nuclear strong interactions and magnetic scattering contribute to the diffraction which is sensitive to the intra-atomic distances. The minimal conclusion is that the protons form a separate phase with inter-proton distance sufficiently different from that between water molecules and are not seen in neutron and electron diffraction in the atto-second time scale at which protons of water molecule are visible. The stronger conclusion is that they are dark with respect to nuclear strong interactions.

The previous considerations inspired by the model of nuclei as nuclear strings suggests possible explanations.

1. Hydrogen atoms form analogs of nuclear strings connected by color bonds.

2. Nuclear protons form super-nuclei connected by dark color bonds or belong to such super-nuclei (possibly consisting of ^4He nuclei). If color bonds are negatively charged, closed nuclear strings of this kind are neutral and not visible in electron scattering: this assumption is however un-necessarily strong for invisibility in diffractive scattering in atto-second time scale. Only the field bodies of proton carrying weak and color fields could be dark and electromagnetic field body has ordinary value of Planck constant so that dark protons could give rise to ordinary hydrogen atoms.

6.2.2 Could also the color flux tubes connecting quarks inside dark protons be dark?

The first option is that only the color flux tubes connecting protons are dark and of length of atomic size scale. The second possibility is that also the color flux tubes connecting quarks are dark and have length of order atomic size scale. Dark nucleons could be visualized as strings formed from three quarks of order atom size scale connected by color flux tubes. The generalization of the nuclear string model leads to a model of dark nucleon discussed in detail [L2, K16, K38], [L2]. Dark nucleons would in turn form dark nuclei as string like objects.

The amazing finding is that the states of nucleon assumed to be neutral (for definiteness) are in one-one-correspondence with DNA, RNA, mRNA, tRNA and amino-acids and that a physically natural pairing of DNA codons and amino-acids exists and consistent with vertebrate genetic code. Same applies also to nucleons having the charge of proton. The nuclear strings formed from either dark neutrons or dark protons could in principle realize genetic code. This realization would be more fundamental than the usual chemical realization and would force to modify profoundly the ideas about prebiotic evolution. The prebiotic evolution could be evolution of water and the recent evolution could involve genetic engineering based on virtual world experimentation with the dark variant variant of the genetic apparatus. The minimum requirement would be the transcription of at dark DNA defined by nuclear strings to ordinary DNA. Dark nuclear strings could be able to diffuse without difficulties through cell membranes and the transcription of the dark genes to ordinary ones followed by gluing and pasting to genome could make possible the genetic engineering at the level of germ cells.

Another natural hypothesis is that the magnetic bodies assignable to the nuclear strings are responsible for water memory [K16] and that the mechanism of water memory relies on the mimicry of biologically active molecules by dark proton strings. The frequencies involved with water memory are low and nothing to do with molecular energy levels. This is consistent with the identification as cyclotron frequencies so that it would be enough to mimic only the cyclotron spectrum. The mechanism would be similar to that of entrainment of brain to external frequencies and based on the variation of the thickness of magnetic flux tubes or sheets inducing the change of magnetic field and cyclotron frequency. One could perhaps say that magnetic bodies of dark genes as living creatures with some amount of intelligence and ability to planned actions. The evolution of cells up to the neurons of cortex could be accompanied by the evolution of the magnetic bodies of dark nuclear strings realized as the emergence of higher values of Planck constant.

Concerning the mechanism of the debated homeopathic effect itself the situation remains unclear. Homeopathic remedy is obtained by a repeated dilution and succussion of the solution containing the molecules causing the symptoms of the disease [K16]. If the cyclotron frequencies of the magnetic body alone are responsible for the biological effect, one can wonder why the homeopathic remedy does not have the same undesired effects as the original molecule. A more reasonable hypothesis is that the cyclotron frequency spectrums serves only as a signature of the molecule

and the homeopathic remedy only activates the immune system of the organism by cheating it to believe that the undesired molecules are present. The immune system is known to be subject to very fast genetic evolution, and dark nuclear strings forming representations of biologically active molecules and dark genome could be actively involved with this evolution.

What inspires to take these speculations more than as a poor quality entertainment is that the recent findings of the group led by HIV Nobelist Montagnier related to water memory provide support for the hypothesis that a nonstandard realization of genetic code indeed exists [I5]. These findings will be discussed later in this section.

6.2.3 Model for super-nuclei formed from dark protons

Dark protons could form super nuclei with nucleons connected by dark color bonds with $\hbar = r\hbar_0$ with $r = 2^{k_d}$, $k_d = 151 - 127 = 24$. The large distance between protons would eliminate isospin dependent strong force so that multi-proton states are indeed possible. The interpretation would be that nuclear p-adic length scale is zoomed up to $L(113+24 = 137) \sim .78$ Angstroms. Dark color bonds could also connect different nuclei. The earlier hypothesis $r = 2^{11k}$ encourages to consider also $k_d = 22$, which is also one of the favored dark scalings allowed by Mersenne hypothesis $(22 = 18 + 4 = 107 - 89 + 167 - 163)$ giving p-adic scale .39 Angstroms.

The predictions of the model for bond energy depend on the transformation properties of E_s under the scaling of $\hbar$.

1. For small perturbations harmonic oscillator approximation $V \propto kR^2/2 \propto \alpha R^2/2$ makes sense and is invariant under the scalings $\alpha_s \to \alpha_s/r$ and $R \to \sqrt{r}R$ -at least if the scalings are not too large. Bonds with different values of Planck constant have nearly identical energies, which would be indeed consistent with the idea about criticality against the change of Planck constant.

   One can arrive the same conclusion follows also in different manner. The parameter ω corresponds to a quantity of form $\omega = v/L$, where L is a characteristic length scale and v a characteristic velocity. The scaling law of homeopathy [K16] would suggest the dependence $v = c/\sqrt{r}$ and $L \propto \sqrt{r}L$ giving predicting that energy is invariant.

   The result also conforms with the idea that classical perturbative theory does not involve Planck constant. This behavior does not however allow to identify hydrogen as color bonds since the resulting bond energies would be in MeV range.

2. The interpretation of E_s as color Coulombic potential energy α_s/R would suggest that E_s behaves under scaling like the binding energy of hydrogen atom ($1/r^2$ scaling). This interpretation implies non-perturbative effects since in semiclassical approximation energy should not depend on r. Color force is non-perturbative so that one can defend this assumption.

   (a) For $k_d = 24$ E_s would be about.12 eV and considerably lower than the nominal energy of the hydrogen bond.

   (b) For $k_d = 22$ one would obtain energy .48 eV. This energy is same as the universal metabolic energy quantum so that the basic metabolic processes might involve transitions dark-ordinary transition for protons. This would however suggest that the length of color bond is same as that of hydrogen bond so that the protons in question would not be invisible in diffraction in atto-second time scale. The interpretation of color bonds between atoms as hydrogen bonds is much more attractive. Of course, for large values of Planck the invariance of oscillator spectrum implies very large force constant so that the color bond would become very rigid.

These two interpretations are not contradictory if one interprets the non-perturbative contribution to the color binding energy as an additional constant contribution to the harmonic oscillator Hamiltonian which does not contribute the spectrum of excitations energies but only to the ground state energy.

6.2.4 The notion of flux tube state

An approach based more heavily on first principles that the above order of magnitude estimates is inspired by two steps of progress several years after these speculations.

1. Weak form of electric-magnetic duality

The weak form of electric magnetic duality led to an identification of a concrete mechanism of electroweak screening based on the pairing of homological Kähler magnetic monopoles formed by fermion wormhole throats with oppositely magnetically charged wormhole throats carrying quantum numbers of neutrino pair and screening the weak isospin and leaving only electromagnetic charge.

1. The size scale of the Kähler magnetic flux tubes connecting the magnetic monopoles would be of order intermediate gauge boson Compton length. For dark variants of elementary fermions it would be scaled up by $\sqrt{\hbar/\hbar_0}$. The new weak physics involving long range weak fields would be associated with magnetic flux tube like structures. Same conclusion applies also to new QCD type physics since also color confinement would be accompanied Kähler magnetic confinement. This allows to pose very strong restrictions on the models. For instance, it is quite possible that the notion of neutrino atom does not make sense expect if one can assume that the dark quarks feed their weak Z^0 gauge fluxes through a spherically symmetric flux collection of radial flux tubes allowing Coulombic Z^0 gauge potential as an approximate representation inside the radius defined by the length of the flux tubes.

2. It is important to notice that the screening leaves the vectorial coupling to classical Z^0 field proportional to $sin^2(\theta_W)Q_{em}$. This could have non-trivial physical implications perhaps allowing to kill the model.

   (a) For space-time surfaces near vacuum extremals the classical Z^0 fields are strong due to the condition that the induced Kähler field is very weak. More explicitly, from the equations for classical induced gauge fields in terms of Kähler form and classical Z^0 field [L1], [L1]

   $$\gamma = 3J - \tfrac{p}{2}Z^0 \quad , \quad Q_Z = I_L^3 - pQ_{em} \quad , \quad p = sin^2(\theta_W) \tag{6.1}$$

   it follows that for the vacuum extremals the part of the classical electro-weak force proportional to the electromagnetic charge vanishes for $p = 0$ so that only the left-handed couplings to the weak gauge bosons remain. The vanishing of induced Kähler form gives

   $$Z^0 \quad = \quad -\frac{2}{p}\gamma \ . \tag{6.2}$$

   The condition implies very large effective coupling to the classical electromagnetic field since electromagnetic charge is effectively replaced with

   $$Q_{em,eff} \quad = \quad Q_{em} - \frac{2}{p}(I_L^3 - pQ_{em}) \ . \tag{6.3}$$

   (b) The proposed model for cell membrane as a Josephson junction relies on almost vacuum extremals and dark nuclei in the sense that the weak space-time sheet associated with the nuclei of biological important ions (at least) are dark [K28]. It is is assumed that quarks are dark in the length scale considered so that also their weak isospin remains unscreened. In the case of nuclei this means that there is contribution from the vectorial part of weak isospin given by $(Z-N)/4$ proportional to the difference of proton number and neutron number. The dominating contribution comes from Q_{em} term for heavier nuclei. It is essential that weak space-time sheets of electrons are assumed to be ordinary.

(c) One can ask whether the nuclei could be ordinary nuclei. If so, one must still assume that the electrons of the nuclei do not couple to the classical fields assignable to the cell membrane space-time sheet since without this assumption the coupling to Z^0 field would be proportional to the total em charge of the ion rather than nuclear em charge. It is difficult to justify this assumption. In any case, for this option I_L^3 contribution would be totally absent. This affects the effective couplings of biologically important ions to the membrane potential somewhat and modifies the nice quantitative predictions of the model of photoreceptors predicting correctly the frequencies of visible light with maximal response.

2. The notion of flux tube state

The TGD inspired explanation for the finding that the measurement of Lamb shift for muonic hydrogen atom gives proton radius which is 4 per cent smaller than that deducible from ordinary hydrogen atom led to the notion of flux tube state in which muon or electric is confined inside flux tube [K21]. In non-relativistic approximation based on Schrödinger equation, the model leads to wave functions expressible in terms of Airy and "Bairy" functions and WKB approximation allows to deduce an estimate for the energy eigenvalue spectrum. This model works as such also as a model for flux tubes states in which also classical electroweakandcolor fields are involved. Color holonomy is quite generally Abelian for classical color fields and for 2-D CP_2 projection electroweak fields are also Abelian so that the model is expected to be mathematically reasonably simple even when induced spinors are assumed.

The concept of flux tube state is very general and allow to model at least some chemical bonds. In particular, valence bonds might allow description as flux tube states of valence electrons. Hydrogen bonds are responsible for the clustering of water molecules and an obvious question is whether these bonds could be modeled as dark flux tube states of valence electrons. The model is testable since one can predict the energy spectrum of excited states for given thickness of the flux tube and the value of electric flux through it. Also the flux tube states of say electrons assignable to the magnetic flux tubes assumed to connect DNA nucleotides and lipids of cell membrane in the model of DNA as topological quantum computer [K11] could be relevant.

6.2.5 Two kinds of bonds are predicted

Duppose that dark bonds are associated with the electro-magnetic field body. If classical Z^0 field vanishes, em field is proportional to Kähler field as are also the components of the classical color field. The bonds involving classical color gauge fields could have quark and antiquark at the opposite ends of the flux tube as the source of the color gauge field. This is indeed assumed in the model of DNA as topological quantum computer [K11].

If one wants vanishing or very weak color gauge fields, one must allow almost vacuum extremals. This implies that classical Z^0 force is strong and the situation assumed to prevail for the cell membrane would hold also for hydrogen bonds. For almost vacuum extremals the ratio of electric and Z^0 fluxes is so small- of order 1/50 for the small value of Weinberg angle $p = .0295$ (rather than $p \simeq .23$) if appearing as the parameter of the model. The molecule can serve as the source of classical Z^0 and electromagnetic fields in two manners.

1. The almost vacuum flux tubes could have many neutrino state and its conjugate at the opposite ends of the flux tube acting as the source of the classical Z^0 field. This kind of flux tubes would traverse through the cell membrane.

2. The molecule would be accompanied by two kinds of flux tubes. Some of them would be almost vacuum extremals carrying an electric flux much smaller than elementary charge e. Some of them would be accompanied by very weak Z^0 field and electromagnetic field plus color gauge fields generated by the above mechanism. These flux tubes would connect cell membrane and genome.

6.2.6 Two kinds of hydrogen bonds

There is experimental evidence for two different hydrogen bonds. Li and Ross represent experimental evidence for two kinds of hydrogen bonds in ice in an article published in Nature 1993 [D23].

The ratio of the force constants K associated with the bonds is 1: 2.

The proposed scaling law $\omega \to \omega/r$ predicts $\omega \propto 1/r$ so that $k_d \to k_d + 1$ would explain the reduction of the force constant by factor 1/2. The presence of two kinds of bonds could be also seen as a reflection of quantum criticality against change of Planck constant.

Can one understand the finding in terms of dark color bonds?

1. The model is consistent with the identification of the two bonds in terms different values of Planck constant. The proposed scaling law for ω predicts $\omega \propto 1/r$ so that $k_d \to k_d + 1$ would explain the reduction of the force constant by factor 1/2. above described general model for which bond energy contains perturbative harmonic oscillator contribution and non-perturbative Coulombic contribution.

2. The identification of hydrogen bond as dark color bond is however questionable. If bond energy contains a color binding energy scaling as $1/r^2$ contributing only constant shift to the harmonic oscillator Hamiltonian, the behavior of the force constant is consistent with the model. If one assumes that the harmonic oscillator spectrum remains invariant under large scalings of $\hbar$, the force constant becomes extremely strong and the color bond would be by a factor r^2 more rigid than hydrogen bond if one takes seriously the proposed estimates for the value of r. The alternative interpretation would be in terms of almost vacuum extremal property reducing the force constant to a very small value already from the beginning.

The possibility to divide the bonds to two kinds of bonds in an arbitrary manner brings in a large ground state degeneracy given by $D = 16!/(8!)^2$ unless additional symmetries are assumed and give for the system spin glass like character and explain large number of different amorphous phases for ice [D24]. This degeneracy would also make possible information storage and provide water with memory.

6.2.7 Hydrogen bonds as color bonds between nuclei?

The original hypothesis was that there are two kinds of hydrogen bonds: dark and "ordinary". The finding that the estimate for the energy of dark nuclear color bond with $k_d = 22$ equals to the energy of typical hydrogen bond raises the question whether all hydrogen bonds are associated with color bonds between nuclei. Color bond would bind the proton to electronegative nucleus and this would lead to to the formation of hydrogen bond at the level of valence electrons as hydrogen donates its electron to the electronegative atom. The electronic contribution would explain the variation of the bond energy.

If hydrogen bonds connect H-atom to O-atom to acceptor nucleus, if E_s for p-O bond is same as for p-n color bond, and if color bonds are dark with $k_d = 22$, the bond energy $E_s = .5$ eV. Besides this one must assume that the oscillator energy is very small and comparable to the energy of hydrogen bond - this could be due to almost vacuum extremal property.

Dark -possibly (almost unavoidably) colored or weakly charged- bonds could serve as a prerequisite for the formation of electronic parts of hydrogen bonds and could be associated also with other molecular bonds so that dark nuclear physics might be essential part of molecular physics. Dark color bonds could be also charged which brings in additional exotic effects. The long range order of hydrogen bonded liquids could due to the ordinary hydrogen bonds. An interesting question is whether nuclear color bonds could be responsible for the long range order of all liquids. If so dark nuclear physics would be also crucial for the understanding of the condensed matter.

In the case of water the presence of dark color bonds between dark protons would bring in additional long range order in length scale of order 10 Angstrom characteristic for DNA transversal scale: also hydrogen bonds play a crucial role in DNA double strand. Two kinds of bond networks could allow to understand why water is so different from other molecular liquids containing also hydrogen atoms and the long range order of water molecule clusters would reflect basically the long range order of two kinds of dark nuclei.

Recall that the model for dark nucleons predicts that nucleon states can be grouped to states in one-one correspondence with DNA, RNA, tRNA, and amino-acids and that the degeneracies of the vertebrate genetic code are predicted correctly. This led to suggestion that genetic code is realized already at the level of dark nuclei consisting of sequences of neutrons [L2, K38], [L2] . Neutrons were assumed in order to achieve stability and could be replaced with protons.

6.2.8 Tedrahedral and icosahedral clusters of water molecules and dark color bonds

Water molecules form both tetrahedral and icosahedral clusters. ^4He corresponds to tetrahedral symmetry so that tetrahedral cluster could be the condensed matter counterpart of ^4He. It the nuclear string model nuclear strings consist of maximum number of ^4He nuclei themselves closed strings in shorter length scale.

The p-adic length scales associated with ^4He nuclei and nuclear string are $k = 116$ and $k = 127$ The color bond between ^4He units has $E_s = .2$ MeV and $r = 2^{22}$ would give by scaling $E_s = .05$ eV which is the already familiar energy associated with cell membrane potential at the threshold for the nerve pulse generation. The binding energy associated with a string formed by n tetrahedral clusters would be n^2E_s. This observation raises the question whether the neural firing is accompanied by the re-organization of strings formed by the tetrahedral clusters and possibly responsible for a representation of information and water memory.

The icosahedral model [D24] for water clusters assumes that 20 tetrahedral clusters, each of them containing 14 molecules, combine to form icosahedral clusters containing 280 water molecules. Concerning the explanation of anomalies, the key observation is that icosahedral clusters have a smaller volume per water molecule than tetrahedral clusters but cannot form a lattice structure.

The number 20 for the dark magic dark nuclei forming the icosahedron is also a magic number and a possible interpretation for tetrahedral and icosahedral water clusters would be as magic super-nuclei and the prediction would be that binding energy behaves as n^2E_s rather than being just the sum of the binding energies of hydrogen bonds (nE_s).

It is interesting to compare this model with the model for hexagonal ice which assumes four hydrogen bonds per water molecule: for two of them the molecule acts as a donor and for two of them as an acceptor. Each water molecule in the vertices of a tetrahedron containing 14 hydrogen atoms has a hydrogen bond to a water molecule in the interior, each of which have 3 hydrogen bonds to molecules at the middle points of the edges of the tetrahedron. This makes 16 hydrogen bonds altogether. If all of them are of first type with bonding energy $E_s = .5$ eV and if the bond network is connected one would obtain total bond energy equal to $n^2E_s = 258 \times .5$ eV rather than only $nE_s = 16 \times .5$ eV. Bonds of second type would have no role in the model.

6.2.9 Tedrahedral and icosahedral clusters and dark electrons

An interesting question is whether one could interpret tetrahedral and icosahedral symmetries in terms of symmetries of the singular coverings or factor spaces of CD. This does not seem to be the case.

1. One cannot understand discrete molecular symmetries for factor space-space option since the symmetry related points of CD would correspond to one and same space-time point.

2. For the option allowing only singular coverings of $CD \times CP_2$ interpreted in terms of many-valuedness of the time derivatives of the imbedding space coordinates as functions of canonical momentum densities this interpretation is not possible.

3. One can also consider the possibility that the singular coverings are over $(CD/G_a)\times(CP_2/G_b)$ rather than $CD \times CP_2$. This would predict Planck constant to be of form $r = n_a n_b$, with $n_a = 3$ for tetrahedral clusters and $n_a = 5$ for icosahedral clusters. n_a and n_b would correspond to the orders of maximal cyclic subgroups of the corresponding symmetry groups. There would be a deviation from the simplest proposal for preferred Planck constants. This option would require space-time surfaces to have exact discrete symmetries and this does not look plausible.

Note that synaptic contacts contain clathrin molecules which are truncated icosahedrons and form lattice structures and are speculated to be involved with quantum computation like activities possibly performed by microtubules. Many viruses have the shape of icosahedron.

It should be noticed that single nucleotide in DNA double strands corresponds to a twist of $2\pi/10$ per single DNA triplet so that 10 DNA strands corresponding to length $L(151) = 10$ nm (cell membrane thickness) correspond to $3 \times 2\pi$ twist. This could be perhaps interpreted as evidence for group C_{10} perhaps making possible quantum computation at the level of DNA.

6.3 Further Comments On 41 Anomalies

Some clarifying general comments -now in more standard conceptual framework- about the anomalies are in order. Quite generally, it seems that it is the presence of new degrees of freedom, the presence of icosahedral clusters, and possibly also macroscopic quantum coherence of dark matter, which are responsible for the peculiar properties of water.

The hydrogen bonds assigned to tetrahedral and icosahedral clusters should be same so that if the hydrogen bonds are assignable to dark protons this is the case for all clusters. Perhaps the number of dark protons and -perhaps equivalently- hydrogen bonds per volume is what distinguishes between these clusters and that the disappearance of dark protons leads to the disappearance of hydrogen bonds. Since it is quite possible that no new physics of proposed kind is involved, the following the explanation of anomalies uses only the notions of icosahedral and tetrahedral clusters and dark protons are mentioned only in passing.

1. Anomalies relating to the presence of icosahedral clusters

Icosahedral water clusters have a better packing ratio than tetrahedral lattice and thus correspond to a larger density. They also minimize energy but cannot cannot form a lattice [D24].

1. This explains the unusually high melting point, boiling point, critical point, surface tension, viscosity, heat of vaporization, shrinking on melting, high density increasing on heating, increase of the number of nearest neighbors in melting and with temperature. It is also possible to understand why X-ray diffraction shows an unusually detailed structure.

   The presence of icosahedral clusters allows to understand why liquid water can be supercooled, and why the distances of water molecules increase under high pressure. The spin glass degeneracy implied by dark and ordinary hydrogen bonds could explain why ice has many glassy amorphous phases. The two phases of super-cooled water could correspond to the binary degree of freedom brought in by two different hydrogen bonds. For the first phase both hydrogen atoms of a given water molecule would be either dark or ordinary. For the second phase the first hydrogen atom would be dark and second one ordinary.

   Since icosahedral clusters have lower energy than a piece of ice of same size, they tend to super-cool and this slows down the transition to the solid phase. The reason why hot water cools faster would be that the number of icosahedral clusters is smaller: if cooling is carried with a sufficient efficiency icosahedral clusters do not form.

2. Pressure can be visualized as a particle bombardment of water clusters tending to reduce their volume. The collisions with particles can induce local transitions of icosahedral structures to tetrahedral structures with a larger specific volume and energy. This would explain the low compressibility of water and why pressure reduces melting point and the temperature of maximum density and viscosity.

3. The increase of temperature is expected to reduce the number of icosahedral clusters so that the effect of pressure on these clusters is not so large. This explains the increase of compressibility with temperature below 46.5°C. The fact that the collapse of icosahedral clusters opposes the usual thermal expansion is consistent with the low thermal expansivity as well as the change of sign of expansivity near melting point. Since the square of sound velocity is inversely proportional to compressibility and density, also the increase of speed of sound with temperature can be understood.

2. The presence of dark degrees of freedom and spin glass degeneracy

The presence of dark degrees of freedom and the degeneracy of dark nucleus ground states could explain the high specific heat capacity of water. The reduction of dark matter degrees of freedom for ice and steam would explain why water has over twice the specific heat capacity of ice or steam. The possibility to relax by dissipating energy to the dark matter degrees of freedom would explain the short spin-lattice relaxation time. The fact that cold water has more degrees of freedom explains why warm water vibrates longer than cold water.

Also the high thermal and electric conductivity of water could be understood. The so called Grotthuss [I2] [D24] explaining OH_- and H_+ mobilities (related closely to conductivities) is based

on hopping of electron of OH_- and H_+ in the network formed by hydrogen bonds and generalizes to the recent case. The reduction of conductivity with temperature would be due to the storage of the transferred energy/capture of charge carriers to the water molecule clusters.

3. Macroscopic quantum coherence

The high value of dielectric constant could derive from the fact that dark nuclei and super-nuclei are quantum coherent in a rather long length scale. For curl free electric fields potential difference must be same along space-time sheets of matter and dark matter. The synchronous quantum coherent collective motion of dark protons (and possible dark electrons) in an oscillating external electric field generates dark photon laser beams (it is not clear yet whether these dark laser beams are actually ordinary laser beams) de-cohering to ordinary photons and yield a large dynamical polarization. As the temperature is lowered the effect becomes stronger.

6.4 The strange properties of water as indication for the existence of dark matter in TGD sense

The motivation for this brief comment came from a popular article telling that a new phase of water has been discovered in the temperature range 50-60 °C (see `http://tinyurl.com/h4wlf6o`. Also Gerald Pollack [L5] (see `http://tinyurl.com/oyhstc2`) has introduced what he calls the fourth phase of water. For instance, in this phase water consists of hexagonal layers with effective $H_{1.5}O$ stoichiometry and the phase has high negative charge. This phase plays a key role in TGD based quantum biology. These two fourth phases of water could relate to each other if there exist a deeper mechanism explaining both these phases and various anomalies of water.

Martin Chaplin (see `http://tinyurl.com/ye77f7d`) has an extensive web page about various properties of water. The physics of water is full of anomalous features and therefore the page is a treasure trove for anyone ready to give up the reductionistic dogma. The site discusses the structure, thermodynamics, and chemistry of water. Even academically dangerous topics such as water memory and homeopathy are discussed.

One learns from this site that the physics of water involves numerous anomalies (see `http://tinyurl.com/hs77fsh`). The structural, dynamic and thermodynamic anomalies form a nested in density-temperature plane. For liquid water at atmospheric pressure of 1 bar the anomalies appear in the temperature interval 0-100 °C.

Hydrogen bonding creating a cohesion between water molecules distinguishes water from other substances. Hydrogen bonds induce the clustering of water molecules in liquid water. Hydrogen bonding is also highly relevant for the phase diagram of H_2O coding for various thermodynamical properties of water (see `http://tinyurl.com/hr77ou5`). In biochemistry hydrogen bonding is involved with hydration. Bio-molecules - say amino-acids - are classified to hydrophobic, hydrophilic, and amphiphilic ones and this characterization determines to a high extent the behavior of the molecule in liquid water environment. Protein folding represents one example of this.

Anomalies are often thought to reduce to hydrogen bonding. Whether this is the case, is not obvious to me and this is why I find water so fascinating substance.

6.4.1 Examples of anomalies

Some examples about anomalies are in order.

1. The high cohesion between water molecules due to hydrogen bonds gives it exceptionally high freezing and boiling points. The high latent heat of evaporation implied by hydrogen bond gives a high resistance to hydration and high evaporative cooling. Hydrogen bonds also give rise to an especially high surface tension.

   Water has unique hydration properties with respect to the basic biomolecules. Hydration leads to the formation of gels, which can reversibly undergo gel-sol phase transitions important for the physics of life. Water ionizes easily and proton transfer reactions between molecules giving rise to rich interactions in biochemistry.

2. Solid (liquid) water has anomalously low (high) density so that the difference between densities of liquid and solid states is small. In the range 0-4 °C water compresses (becomes more

dense than solid phase) when heated at constant pressure rather than expanding as other liquids. This anomaly is fundamental for life.

3. Water has anomalously high specific heat capacity $c_p = dC_p/dM$, $C_p = (dE/dT)_p$. This might be understood in terms of breaking of hydrogen bonds giving rise to new translational degrees of freedom as water molecules begin to move freely.

   The specific heat capacity c_p of liquid water at atmospheric pressure decreases in the interval 5-37 °C, and increases in the range 37-100 °C. The minimum is at physiological temperature (see `http://tinyurl.com/zfv22yz`) - hardly an accident. For other liquids c_p increases steadily in this interval. The compressibility of water depicts similar behavior distinguishing water from other liquids.

4. Mpemba effect (see `http://tinyurl.com/7h2h59p`) means that hot water freezes faster than cold water. The effect is maximal at 35 °C, which is remarkably close to the physiological temperature. Mpemba effect challenges the naive views about what happens in freezing, and several explanations have been proposed.

6.4.2 The anomalies of water in TGD framework

What TGD can say about these anomalies? I have already earlier considered a model of water explaining some of the basic anomalies and it is interesting to see whether the recent understanding of TGD might allow more precise articulation of the basic ideas.

1. The TGD inspired model assumes that water consists of ordinary water plus dark water. Dark matter is identified in TGD framework as phases of ordinary matter but with effective Planck constant h_{eff}, which is integer multiple $h_{eff}/h = n$ of the ordinary Planck constant. This proposal is motivated by several experimental findings. In particular, Pollack effect leading to a generation of negatively charged exclusion zones (EZs) with effective stoichiometry of water to $H_{1.5}O$ would be due to the transfer of one-over-fourth of protons do dark protons at magnetic flux tubes.

   One must be careful in defining what "dark" means. Does dark matter include only the dark particles at flux tubes or does it include also the water molecules connected by these flux tubes? The following considerations suggest that the latter definition allowing to talk about dark water is more appropriate.

2. The dark matter at magnetic flux tubes could involve also other particles than protons (electrons and even ions) and would serve as the "boss" controlling biochemistry in TGD based view about biology. The communications between visible matter and dark particles at magnetic flux tubes would rely on dark photons with energy $E = h_{eff}f$, which can be above thermal energy for even EEG frequencies. This makes possible interaction between widely different length and time scales.

3. $h_{eff}/h = n$ phases would be generated at quantum criticality and serve as correlates for long range correlations and fluctuations at criticality. The transformation of ordinary protons to dark protons and vice versa could be essential for proton transfer reactions and even give rise to high Tc super-conductivity along dark flux tubes based on pairs of parallel flux tubes carrying the members of Cooper pairs.

4. Several values of h_{eff}/h are possible. The matter visible to us need not correspond to the minimal value of h. The hydrino atoms with scaled up binding energy spectrum claimed by Randell Mills [D20] could be understood if $h_{eff}/h = n$ for ordinary atomics equals to $n = 6$ and hydrino atoms have $n < 6$ [L8].

I am not trying to give any summary about various anomalies of water in the following but consider only the above mentioned examples from TGD point of view. Let us therefore make following assumptions (one could represent these assumptions also as questions).

1. Water consists of ordinary and dark fractions. Several values of $h_{eff}/h = n$ are possible and their fractions depend on pressure and temperature. These two fractions can be present

in both solid and liquid states. The dark fraction of water - say dark proton sequences at magnetic flux tubes leading also to the notion of dark variant of genetic code inducing the ordinary chemical code [L6] - does not interact directly with ordinary water except via classical em fields (this is important!). More generally, phases with different values of n are dark relative to each other. The quantal interactions are only via exchange of dark photons transforming to ordinary photons identified in biology as bio-photons or vice versa. The additional assumption $h_{eff} = h_{gr}$, where h_{gr} is gravitational Planck constant [K42, K41], guarantees that the cyclotron energy spectrum of dark photons is universal and corresponds to that for bio-photons (visible and UV) [K40].

The presence of dark protons implies the generation of negative electronic charge. Could repulsive Coulomb interactions become significant and lead to an expansion of water possibly relevant for the understanding of the anomalously low density of ice?

2. Hydrogen bond is thought to be essential for the understanding of the anomalies. Hydrogen bonds could correspond in TGD framework to short and rigid flux tubes. Large values of n scaling up the flux tube lengths would give rise to longer, possibly loop-like, magnetic flux tubes. Indeed, if the total magnetic energy is not changed the string tension defined as magnetic energy density is reduced like $1/n$. Flux tubes could form a dynamical network in which reconnections and phase transitions changing the value of n would make the topology of the network dynamical.

   This kind of flux tube network could give rise to TGD analog of tensor networks [L7] realizing quantum entanglement between the nodes of the network and to be central for the formation of gel phase explaining the quantum coherence of water in vivo. The generalization of the usual picture behind bio-chemistry in which one has only molecules to a flux tube network having various particles at its nodes would allow to understand the emergence of complexity in both condensed matter physics and biology [L7].

   Hydration, dehydration and gel-sol phase transition could involve a phase transition changing the value of n and transforming the hydrogen bonds to longer flux tubes and vice versa. These phase transitions would be also essential in bio-catalysis. It would seem that the natural formulation for various anomalies would be in terms of the flux tube network, whose connectivity depends on temperature and pressure.

3. Dark particles are generated at quantum criticality and quantum criticality could accompany also ordinary thermal phase transitions such as freezing of water.

4. One can imagine several models for the dark fraction of water. Since the temperature range 0-100 °C involves several anomalies, it is natural to assume that the dark fraction of water varies as function of p and T. It seems also safe to assume that the hydrogen bonding becomes maximal at freezing and the bonds identifiable as flux tubes become short. Since the anomalies are strongest around physiological temperature 37 °C, TGD inspired model of quantum biology suggests that dark fraction is highest near this temperature. One expects several fractions with different values of n depending on temperature and pressure.

5. Why water would be so special? Also other liquids could involve flux tubes but with small value of n and therefore much shorter than those in water. Hydrogen bonds in water would also have larger value of n than for other substances. Heavy water does not share the anomalies of ordinary water although the electronic chemistry is the same. The large mass of deuterium probably prevents the formation of dark deuterium. Maybe the fact that the Compton length of (also dark) deuterium is 1/2 of that for (dark) proton could be significant and prevents the formation of dark deuterium bonds?

   Hydrogen bonds are usually associated with electronegative atoms - usually F, O, and N (see `http://tinyurl.com/bntn28n`). Also hydrogen bond between hydrogen and carbon is possible when C is bound to electronegative atoms (chloroform $CHCl_3$ is one example). Note that H_2S, which is chemical analog of water, can form hydrogen with F but two H_2S molecules do not form hydrogen bonds so that H_2S based life is not possible.

Consider first a model for what could happen in the range $0 - 4$ °C under normal pressure.

1. The presence of negative electronic charge induced by the transfer of dark protons to magnetic flux tubes might explain the larger volume of ice as compared to liquid water above 4 °C. The standard explanation is in terms of hydrogen bonds leading to rigid clusters with average distance between water molecules longer than in ordinary water. If hydrogen bonds correspond to short rigid flux tubes these explanations are consistent. The positive charge of dark protons would generate classical Coulomb fields and neutralize this negative charge non-locally as a kind of smooth background so that neutralization would take place in longer length scale and lead to a lower density.

2. What would happen at the interval $0 - 4$ °C? Do the dark protons at flux tubes assigned to hydrogen bonds transform to ordinary ones and reduce the number of hydrogen bonds and lead to a reduction of the density? Or does the average value of n assignable to the flux tubes increase and increase the average length of flux tubes? Heating would transforms short and rigid flux tubes (hydrogen bonds) to longer and loopy ones. If the magnetic energy is conserved, string tension must scale down by $1/n$ leading to the melting of flux tubes. The melted loopy flux tubes would be longer but their ends could become nearer to each other.

   Melting would thus have a counterpart at the level of magnetic body. Could the freezing of the flux tubes induce the freezing of water? Could the dynamics of ordinary water fraction of water be governed by that of the dark fraction? TGD inspired biology assumes that magnetic body carrying dark matter serves as a template for biochemistry. Could this be true also for thermodynamics?

One can try to explain the anomalies of heat capacity in this picture.

1. Specific heat capacity defined as total heat capacity per mass $c_p = (dC_p/dM)$, $C_p = (dE/dT)_p$ at constant pressure. The large value of c_p for water is thought to be due to the splitting of hydrogen bonds by energy feed so that new translational degrees of freedom are created and the energy feed goes to these.

   Could this intuition generalize? Hydrogen bonds would be replaced with flux tube pairs with members carrying opposite fluxes and carrying dark protons and connecting two water molecules. There would be two phases of matter. Lonely water molecules possibly accompanied by short flux loops and pairs of water molecules connected by flux tube pairs. Also clusters of water molecules connected by flux tubes with several pairs of flux tubes emerging from each molecule are possible. Dark matter could be identified the molecule pairs or groups connected by flux tube pairs distinguishing between water and other liquids.

2. The reconnection for a pair of flux tubes with opposite fluxes creates molecules with U-shaped flux tubes, which could rapidly contract. This would lead to two free molecules of ordinary water. These molecules would take most of the feeded energy ΔE and heat the water by ΔT. Also part of the magnetic energy of the flux tubes would be transferred to the kinetic energy of liberated molecules. This energy could be small for short flux tubes at least. If the phase transition increasing the value of n preserves the total magnetic energy, this energy would be small also for long flux tubes.

3. Suppose that the fraction of flux molecules connected by flux tube pairs - dark matter - increases with temperature. c_p is determined by the rate of reconnections of flux tube pairs effectively transforming two dark water molecule pair to ordinary ones. c_p should be reduced above 4 °C up to 37 °C. The value of the latter temperature suggests an increase of dark matter component so that the number of ordinary water molecules would decrease. The first guess is that the magnetic energy is of the order of the bond energy assignable to hydrogen bond and in the range .023-.05 eV. Note that membrane voltage eV corresponds to energy which is same order of magnitude. This interpretation is natural if the creation and annihilation of flux tube pairs is basic mechanism of biology.

   The reconnection creates more ordinary water molecule pairs and only these absorb heat. The absorbed heat is shared between the ordinary water molecules. The energy is shared by a smaller number of ordinary water molecules so that ΔT for given ΔE is higher and c_p is smaller. Note that also the fact that total mass $M = M_{ord} + M_{dark}$ of water is larger than M_{ord} reduces c_p.

4. Why c_p would increase above 37 °C? The most straightforward explanation is that dark matter - that is the molecules connected by flux tube pairs begins to decrease above this temperature. The amount of dark matter - the connectivity of the web formed by flux tubes - is highest at 37 °C. The splitting of the flux tube pairs to pairs of loops would explain disappearance of dark matter above 37 °C. The heat is shared between larger number of ordinary molecules and ΔT is smaller for a given ΔE so that c_p becomes larger. Also the reduction of M_{dark} has similar effect.

Consider next the anomalous behavior of compressibility.

1. The reduction of compressibility K ($\Delta V = -(dlog(V)/dp)\Delta p = -K\Delta p$), which at zero pressure limit is maximal at 45 °C should have an explanation along the same lines. Compressibility is reduced if the increase in pressure produces ordinary water molecules, whose emergence tends to increase the volume filled n by ordinary water molecules. This is the case if the fraction of dark matter decreases with increasing pressure. The reason could be splitting of the flux tube pairs to loops. This predicts that anomalies are absent for high enough pressures as they indeed are.

2. What happens in evaporation? It would seem that the density of dark matter fraction becomes so small that the flux tube connections cannot anymore create the needed cohesion and water evaporates. Note that also the connectivity of the flux tube web is reduced.

What about Mpemba effect (see `http://tinyurl.com/7h2h59p`)? Why hot water would freeze faster than cold water and why the effect would be strongest around 35 °C?

1. The amount of dark matter seems to be essential for the effect. A possible mechanism of freezing would be reduction of lengths of dark flux tube pairs by quantum phase transitions reducing the value of n. This mechanism would contract the flux tubes to hydrogen bonds very rapidly. The resulting ice would serve as seeds inducing the freezing of the ordinary portion of water. Freezing would be fastest around 35 °C.

2. The freezing of dark portion eliminates it. The condition that dark and ordinary portion of water are in kinetic equilibrium could induce the transformation of ordinary matter to dark matter. If this process is fast enough, the freezing could take place via the cycle *ordinary water* $\rightarrow$ *dark water* $\rightarrow$ *ice* and be faster than freezing near freezing point where dark matter fraction is small.

6.5 Genes And Water Memory

After long time I had opportunity to read a beautiful experimental article about experimental biology. Yolene Thomas, who worked with Benveniste, kindly sent the article to me. The freely loadable article is *Electromagnetic Signals Are Produced by Aqueous Nanostructures Derived from Bacterial DNA Sequences* by Luc Montagnier, Jamal Aissa, Stephane Ferris, Jean-Luc Montagnier, and Claude Lavall'e published in the journal Interdiscip. Sci. Comput. Life Sci. (2009) [I5].

6.5.1 Basic findings at cell level

I try to list the essential points of the article. Apologies for biologists: I am not a specialist.

1. Certain pathogenic micro-organisms are objects of the study. The bacteria Mycoplasma Pirum and E. Choli belong to the targets of the study. The motivating observation was that some procedures aimed at sterilizing biological fluids can yield under some conditions the infectious micro-organism which was present before the filtration and absent immediately after it. For instance, one filtrates a culture of human lymphocytes infected by M. Pirum, which has infected human lymphocytes to make it sterile. The filters used have 100 nm and 20 nm porosities. M. Pirum has size of 300 nm so that apparently sterile fluids results. However if this fluid is incubated with a mycoplasma negative culture of human lymphocytes, mycoplasma re-appears within 2 or 3 weeks! This sounds mysterious. Same happens as 20 nm filtration is applied to a a minor infective fraction of HIV, whose viral particles have size in the range 100-120 nm.

2. These findings motivated a study of the filtrates and it was discovered that they have a capacity to produce low frequency electromagnetic waves with frequencies in good approximation coming as the first three harmonics of kHz frequency, which by the way plays also a central role in neural synchrony. What sounds mysterious is that the effect appeared after appropriate dilutions with water: positive dilution fraction varied between 10^{-7} and 10^{-12}. The uninfected eukaryotic cells used as controls did not show the emission. These signals appeared for both M. Pirum and E. Choli but for M. Pirum a filtration using 20 nm filter canceled the effect. Hence it seems that the nano-structures in question have size between 20 and 100 nm in this case.

   A resonance phenomenon depending on excitation by the electromagnetic waves is suggested as an underlying mechanism. Stochastic resonance familiar to physicists suggests itself and also I have discussed it while developing ideas about quantum brain [K29]. The proposed explanation for the necessity of the dilution could be kind of self-inhibition. Maybe a gel like phase which does not emit radiation is present in sufficiently low dilution but is destroyed in high dilutions after which emission begins. Note that the gel phase would not be present in healthy tissue. Also a destructive interference of radiation emitted by several sources can be imagined.

3. Also a cross talk between dilutions was discovered. The experiment involved two tubes. Donor tube was at a low dilution of E. Choli and "silent" (and carrying gel like phase if the above conjecture is right). Receiver tube was in high dilution (dilution fraction 10^{-9}) and "loud". Both tubes were placed in mu-metal box for 24 hours at room temperature. Both tubes were silent after his. After a further dilution made for the receiver tube it became loud again. This could be understood in terms of the formation of gel like phase in which the radiation does not take place. The effect disappeared when one interposed a sheath of mu-metal between the tubes. Emission of similar signals was observed for many other bacterial specials, all pathogenic. The transfer occurred only between identical bacterial species which suggests that the signals and possibly also frequencies are characteristic for the species and possibly code for DNA sequences characterizing the species.

4. A further surprising finding was that the signal appeared in dilution which was always the same irrespective of what was the original dilution.

6.5.2 Experimentation at gene level

The next step in experimentation was performed at gene level.

1. The killing of bacteria did not cancel the emission in appropriate dilutions unless the genetic material was destroyed. It turned out that the genetic material extracted from the bacteria filtered and diluted with water produced also an emission for sufficiently high dilutions.

2. The filtration step was essential for the emission also now. The filtration for 100 nm did not retain DNA which was indeed present in the filtrate. That effect occurred suggests that filtration destroyed a gel like structure inhibiting the effect. When 20 nm filtration was used the effect disappeared which suggests that the size of the structure was in the range 20-100 nm.

3. After the treatment by DNAse enzyme inducing splitting of DNA to pieces the emission was absent. The treatment of DNA solution by restriction enzyme acting on many sites of DNA did not suppress the emission suggesting that the emission is linked with rather short sequences or with rare sequences.

4. The fact that pathogenic bacteria produce the emission but not "good" bacteria suggests that effect is caused by some specific gene. It was found that single gene - adhesin responsible for the adhesion of mycoplasma to human cells- was responsible for the effect. When the cloned gene was attached to two plasmids and the E. Choli DNA was transformed with the either plasmid, the emission was produced.

6.5.3 Some consequences

The findings could have rather interesting consequences.

1. The refinement of the analysis could make possible diagnostics of various diseases and suggests bacterial origin of diseases like Alzheimer disease, Parkinson disease, Multiple Sclerosis and Rheumatoid Arthritis since the emission signal could serve as a signature of the gene causing the disease. The signal can be detected also from RNA viruses such as HIV, influenza virus A, and Hepatitis C virus.

2. Emission could also play key role in the mechanism of adhesion to human cells making possible the infection perhaps acting as a kind of password.

The results are rather impressive. Some strongly conditioned skeptic might have already stopped reading after encountering the word "dilution" and associating it with a word which no skeptic scientist in his right mind should not say aloud: "homeopathy" ! By reading carefully what I wrote above, it is easy to discover that the experimenters unashamedly manufactured a homeopathic remedy out of the filtrate! And the motivating finding was that although filtrate should not have contained the bacteria, they (according to authors), or at least the effects caused by them, appeared within weeks to it! This is of course impossible in the word of skeptic.

The next reaction of the skeptic is of course that this is fraud or the experimenters are miserable crackpots. Amusingly, one of the miserable crackpots is Nobelist Luc Montagnier, whose research group discovered AIDS virus.

6.5.4 How TGD could explain the findings?

Let us leave the raging skeptics for a moment and sketch possible explanations in TGD framework.

1. Skeptic would argue that the filtration allowed a small portion of infected cells to leak through the filter. Many-sheeted space-time suggests a science fictive variant of this explanation. During filtration part of the infected cells is "dropped" to large space-time sheets and diffused back to the original space-time sheets during the next week. This would explain why the micro-organisms were regenerated within few weeks. Same mechanism could work for ordinary molecules and explain homeopathy. This can be tested: look whether the molecules return back to the diluted solution in the case of a homeopathic remedy.

2. If no cells remain in the filtrate, something really miraculous looking events are required to make possible the regeneration of the effects serving as the presence of cells. This even in the case that DNA fragments remain in the filtrate.

   (a) The minimum option is that the presence of these structures contained only the relevant information about the infecting bacteria and this information coded in terms of frequencies was enough to induce the signatures of the infection as a kind of molecular conditioning. Experimentalists can probably immediately answer whether this can be the case.

   (b) The most radical option is that the infecting bacteria were actually regenerated as experimenters claim! The information about their DNA was in some form present and was transcribed to DNA and/or RNA, which in turn transformed to proteins. Maybe the small fragment of DNA (adhesin) and this information should have been enough to regenerate the DNA of the bacterium and bacterium itself. A test for this hypothesis is whether the mere nanoparticles left from the DNA preparation to the filtrate can induce the regeneration of infecting molecules.

The notion of magnetic body carrying dark matter quantum controlling living matter forms the basic element of TGD inspired model of quantum biology and suggests a more concrete model. The discovery of nanotubes connecting cells with distance up to 300 μ [I1] provides experimental support for the notion.

1. If the matter at given layer of the onion-like structure formed by magnetic bodies has large $\hbar$, one can argue that the layer corresponds to a higher evolutionary level than ordinary matter with longer time scale of memory and planned action. Hence it would not be surprising if the magnetic bodies were able to replicate and use ordinary molecules as kind of sensory receptors and motor organs. Perhaps the replication of magnetic bodies preceded the replication at DNA level and genetic code is realized already at this more fundamental level somehow. Perhaps the replication of magnetic bodies induces the replication of DNA as I have suggested.

2. The magnetic body of DNA could make DNA a topological quantum computer [K11]. DNA itself would represent the hardware and magnetic bodies would carry the evolving quantum computer programs realized in terms of braidings of magnetic flux tubes. The natural communication and control tool would be cyclotron radiation besides Josephson radiation associated with cell membranes acting as Josephson junctions. Cyclotron frequencies are indeed the only natural frequencies that one can assign to molecules in kHz range. There would be an entire fractal hierarchy of analogs of EEG making possible the communication with and control by magnetic bodies.

3. The values of Planck constant would define a hierarchy of magnetic bodies which corresponds to evolutionary hierarchy and the emergence of a new level would mean jump in evolution. Gel like phases could serve as a correlate for the presence of the magnetic body. The phase transitions changing the value of Planck constant and scale up or down the size of the magnetic flux tubes. They are proposed to serve as a basic control mechanism making possible to understand the properties and the dynamics of the gel phases and how biomolecules can find each other in the thick molecular soup via a phase transition reducing the length of flux tubes connecting the biomolecules in question and thus forcing them to the vicinity of each other.

Consider now how this model could explain the findings.

1. Minimal option is that the flux tubes correspond to "larger space-time sheets" and the infected cells managed to flow into the filtrate along magnetic flux tubes from the filter. This kind of transfer of DNA might be made possible by the recently discovered nanotubes already mentioned.

2. Maybe the radiation resulted as dark photons invisible for ordinary instruments transformed to ordinary photons as the gel phase assignable with the dark matter at magnetic flux tube network associated with the infected cells and corresponding DNA was destroyed in the filtration.

   This is not the only possible guess. A phase conjugate cyclotron radiation with a large value of Planck constant could also allow for the nanostructures in dilute solute to gain metabolic energy by sending negative energy quanta to a system able to receive them. Indeed the presence of ambient radiation was necessary for the emission. Maybe that for sufficiently dilute solute this mechanism allows to the nanostructures to get metabolic energy from the ambient radiation whereas for the gel phase the metabolic needs are not so demanding. In the similar manner bacteria form colonies when metabolically deprived. This sucking of energy might be also part of the mechanism of disease.

3. What could be the magnetic field inducing the kHz radiation as a synchrotron radiation?

   (a) For instance, kHz frequency and its harmonics could correspond to the cyclotron frequencies of proton in magnetic field which field strength slightly above that for Earth's magnetic field (750 Hz frequency corresponds to field strength of B_E, where $B_E = .5$ Gauss, the nominal strength of Earth's magnetic field). A possible problem is that the thickness of the flux tubes would be about cell size for Earth's magnetic field from flux quantization and even larger for dark matter with a large value of Planck constant. Of course, the flux tubes could make themselves thinner temporarily and leak through the pores.

(b) If the flux tube is assumed to have thickness of order 20-100 nm, the magnetic field for ordinary value of $\hbar$ would be of order.1 Tesla from flux quantization and in the case of DNA the cyclotron frequencies would not depend much on the length of DNA fragment since the it carries a constant charge density. Magnetic field of order.2 Tesla would give cyclotron frequency of order kHZ from the fact that the field strength of.2 Gauss gives frequency of about.1 Hz. This correspond to a magnetic field with flux tube thickness $\sim$ 125 nm, which happens to be the upper limit for the porosity. Dark magnetic flux tubes with large $\hbar$ are however thicker and the leakage might involve a temporary phase transition to a phase with ordinary value of $\hbar$ reducing the thickness of the flux tube. Perhaps some genes (adhesin) plus corresponding magnetic bodies representing DNA in terms of cyclotron frequencies depending slightly on precise weight of the DNA sequence and thus coding it correspond to the frequency of cyclotron radiation are the sought for nano-structures.

4. While developing a model for homeopathy based on dark matter I ended up with the idea that dark matter consisting of nuclear strings of neutrons and protons with a large value of $\hbar$ and having thus a zoomed up size of nucleon could be involved. The really amazing finding was that nucleons as three quark systems allow to realize vertebrate code in terms of states formed from entangled quarks [L2], [L2] described also in this chapter! One cannot decompose codons to letters as in the case of the ordinary genetic code but codons are analogous to symbols representing entire words in Chinese. The counterparts of DNA, RNA, and amino-acids emerge and genetic code has a concrete meaning as a map between quantum states.

   Without any exaggeration this connection between dark hadronic physics and biology has been one of the greatest surprises of my professional life. It suggests that dark matter in macroscopic quantum phase realizes genetic code at the level of nuclear physics and biology only provides one particular (or probably very many as I have proposed) representations of it. If one takes this seriously one can imagine that genetic information is represented by these dark nuclear strings of nanoscopic size and that there exists a mechanism translating the dark nuclei to ordinary DNA and RNA sequences and thus to biological matter. This would explain the claimed regeneration of the infected cells.

5. Genetic code at dark matter level would have far reaching implications. For instance, living matter - or rather, the magnetic bodies controlling it - could purposefully perform genetic engineering. This forces me to spit out another really dirty word, "Lamarckism" ! We have of course learned that mutations are random. The basic objection against Lamarckism is that there is no known mechanism which would transfer the mutations to germ cells. In the homeopathic Universe of TGD the mutations could be however performed first for the dark nucleon sequences. After this these sequences would diffuse to germ cells just like homeopathic remedies do, and after this are translated to DNA or RNA and attach to DNA.

The findings of both Montagnier and Gariaev suggests that also the representation of genetic code in terms of dark photons is involved. How genetic code could be represented in terms of frequencies? The TGD based model of music harmony [L4] [K27] (see `http://tinyurl.com/zg3aaj7`) relies on the idea that 12-note scale is representable as a closed non-self-intersecting curve (Hamilton's cycle) at icosahedron having 12 vertices. The harmony assignable to a given Hamilton's cycle is characterized in terms of 3-chords assignable to the 20 faces (triangles) of the icosahedron once the 12-note scale is represented as a particular Hamilton's cycle.

Remarkably, the number of amino-acids is also 20! One indeed ends up with a model in which 20+20+20=60 DNA codons are represented by 3-chords for a triplet of harmonies defined by Hamilton's cycles predicting correctly the numbers of DNAs coding for a given amino-acid for vertebrate code. One must however assume that also tetrahedral harmony is present to get 64 DNA codons rather than only 60. TActually two variants of the code are predicted and altogether one obtains the standard 20 amino-acids plus two additional ones identified as Pyl and Sec known to be realized in living matter.

In music realization DNA codons can be represented as 3 dark photons or phonons with appropriate frequency ratios. This representation could explain the findings of Montagnier and Gariaev.

There is also a connection with TGD inspired theory of consciousness. Music both expresses and induces emotions. The proposal is that the representation of DNA codons in terms of triplets of sounds or dark photons defines molecular level representation of emotions. There is large number of different harmonies and they could represent different moods.

6.6 Burning Water And Photosynthesis

For a physicist liberated from the blind belief in reductionism, biology transforms to a single gigantic anomaly about which recent day physics cannot say much. During years I have constructed several models for these anomalies helping to develop a more detailed view about how the new physics predicted by quantum TGD could allow to understand biology and consciousness.

The basic problem is of course the absence of systematic experimentation so that it is possible to imagine many new physics scenarios. For this reason the article series of Mae-Wan Ho [D29, D27, D25, D28] in ISIS was a very pleasant surprise, and already now has helped considerably in the attempts to develop the ideas further.

The first article "Water electric" [D29] told about the formation of exclusion zones around hydrophilic surfaces, typically gels in the experiments considered [D32]. The zones were in potential of about 100 meV with respect to surroundings (same order of magnitude as membrane potential) and had thickness ranging to hundreds of micrometers (the size of a large cell): the standard physics would suggests only few molecular layers instead of millions. Sunlight induced the effect. This finding allow to develop TGD based vision about how proto cells emerged and also the model for chiral selection in living matter by combining the finding with the anomalies of water about which I had learned earlier.

The article "Can water burn?" [D25] tells about the discovery of John Kanzius - a retired broadcast engineer and inventor. Kanzius found that water literally burns if subjected to a radio frequency radiation at frequency of 13.56 MHz [D1]. The mystery is of course how so low frequency can induce burning. The article "The body does burn water" [D28] notices that plant cells burn water routinely in photosynthesis and that also animal cells burn water but the purpose is now to generate hydrogen peroxide which kills bacteria (some readers might recall from childhood how hydrogen peroxide was used to sterilize wounds!). Hence the understanding of how water burns is very relevant for the understanding of photosynthesis and even workings of the immune system.

6.6.1 Living matter burns water routinely

Photosynthesis burns water by decomposing water to hydrogen and oxygen and liberating oxygen. Oxygen from CO_2 in atmosphere combines with the oxygen of H_2O to form O_2 molecules whereas H from H_2O combines with carbon to form hydrocarbons serving as energy sources for animals which in turn produce CO_2. This process is fundamental for aerobic life. There is also a simpler variant of photosynthesis in which oxygen is not produced and applied by an-aerobic life forms. The article "Living with Oxygen" by Mae-Wan Ho gives a nice overall view about the role of oxygen [D26]. As a matter fact, also animals burn water but they do this to produce hydrogen peroxide H_2O_2 which kills very effectively bacteria.

Burning of water has been studied as a potential solution for how to utilize the solar energy to produce hydrogen serving as a natural fuel [D27]. The reaction $O_2 + H_2 \rightarrow 2H_2O$ occurs spontaneously and liberates energy of about 1.23 eV. The reverse process $2H_2 \rightarrow H_2O_2 + H_2$ in the presence of sunlight means burning of water, and could provide the manner to store solar energy. The basic reaction $2H_2O + 4h\nu \leftrightarrow H_2O_2 + H_2$ stores the energy of four photons. What really happens in this process is far from being completely understood. Quite generally, the mechanisms making possible extreme efficiency of bio-catalysis remain poorly understood. Here new physics might be involved. I have discussed models for photosynthesis and $ADP \leftrightarrow ATP$ process involved with the utilization of the biochemical energy already earlier [K18].

6.6.2 How water could burn in TGD Universe?

The new results could help to develop a more detailed model about what happens in photosynthesis. The simplest TGD inspired sketch for what might happen in the burning of water goes as follows.

1. Assume that 1/4 of water molecules are partially dark (in sense of nonstandard value of Planck constant) or at least at larger space-time sheets in atto-second scale [D24, D22, D31, D21]. This would explain the $H_{1.5}O$ formula explaining the results of neutron diffraction and electron scattering.

2. The question is what this exotic fraction of water precisely is. The models for water electret, exclusion zones and chiral selection lead to concrete ideas about this. Electrons assignable to the H atoms of (partially) dark H_2O reside at space-time sheet $k_e = 151$ (this p-adic length scale corresponds to 10 nm, the thickness of cell membrane). At least the hydrogen atom for this fraction of water molecules is exotic and findings from neutron and electron scattering suggest that both proton and electron are at non-standard space-time sheets but not necessarily at the same space-time sheet. The model for the burning requires that electron and proton are at different space-time sheets in the initial situation.

3. Suppose all four electrons are kicked to the space-time sheet of protons of the exotic hydrogen atoms labeled by k_p. This requires the energy $E_\gamma = (1 - 2^{-n})E_0(k_p)$ (the formula involves idealizations). At this space-time sheet protons and electrons are assumed to combine spontaneously to form two H_2 atoms. Oxygen atoms in turn are assumed to combine spontaneously to form O_2.

4. For $k_f = 148$ and $n = 3$ minimum energy needed would be $4E_\gamma = 4 \times .4 = 1.6$ eV. For $k_p = 149$ (thickness of lipid layer) and $n = 2$ one would have $4E_\gamma = 4 \times .3462 = 1.385$ eV whereas $H_2O_2 + H_2 \to 2H_2O$ liberates energy 1.23 eV. Therefore the model in which electrons are at cell membrane space-time sheet and protons at the space-time sheet assignable to single lipid layer of cell membrane suggests itself. This would also mean that the basic length scales of cell are already present in the structure of water. Notice that there is no need to assume that Planck constant differs from its standard value.

There is no need to add, that the model is an unashamed oversimplification of the reality. It might however catch the core mechanism of photosynthesis.

6.6.3 Burning of salt water induced by RF radiation

Engineer John Kanzius has made a strange discovery [D1]: salt water in the test tube radiated by radio waves at harmonics of a frequency f=13.56 MHz burns. Temperatures about 1500 K, which correspond to.15 eV energy have been reported. One can irradiate also hand but nothing happens. The original discovery of Kanzius was the finding that radio waves could be used to cure cancer by destroying the cancer cells. The proposal is that this effect might provide new energy source by liberating chemical energy in an exceptionally effective manner. The power is about 200 W so that the power used could explain the effect if it is absorbed in resonance like manner by salt water.

Mae-Wan Ho's article "Can water Burn?" [D25] provides new information about burning salt water [D1], in particular reports that the experiments have been replicated. The water is irradiated using polarized radio frequency light at frequency 13.56 MHz. The energy of radio frequency quantum is $E_{rf} = .561 \times 10^{-7}$ eV and provides only a minor fraction $E_{rf}/E = .436 \times 10^{-7}$ of the needed energy which is $E = 1.23$ eV for single $2H_2O \to H_2O_2 + H_2$ event. The structure of water has been found to change, in particular something happens to O-H bonds. The Raman spectrum of the water has changed in the energy range $[0.37, 0.43]$ eV. Recall that the range of metabolic energy quanta $E(k, n) = (1 - 2^-n)E_0(k)$ varies for electron in the range $[.35, .46]$ eV in the model for the formation of exclusion zone induced by light. Therefore the photons assigned to changes in Raman spectrum might be associated with the transfer of electrons between space-time sheets.

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

As I made this proposal, I did not realize the connection with photosynthesis and actual burning of water. The recent experimental findings suggest that dark radio frequency photons transform to

photons inducing splitting of water as in photosynthesis so that that one should have $r = \hbar/\hbar_0 = E_{rf}/4E$. One could say that large number of radio wave photons combine to form a single bundle of photons forming a structure analogous to what mathematician calls covering space. In the burning event the dark photon would transform to ordinary photon with the same energy. This process would thus transform low energy photons to high energy protons with the ratio $r = \hbar/\hbar_0$.

Therefore the mechanism for the burning of water in the experiment of Kanzius could be a simple modification of the mechanism behind burning of water in photosynthesis.

1. Some fraction of dark radio frequency photons are dark or are transformed to dark photons in water and have energies around the energy needed to kick electrons to smaller space-time sheets .4 eV. After this they are transformed to ordinary photons and induce the above process. Their in-elastic scattering from molecules (that is Raman scattering) explains the observation of Raman scattered photons. For a fixed value of $\hbar$ the process would occur in resonant manner since only few metabolic quanta are allowed.

2. How dark radio frequency photons could be present or could be produced in water? Cyclotron radiation assignable to say electrons in magnetic field comes in mind. If the cyclotron radiation is associated with electrons it requires a magnetic field of 4.8 Gauss the cyclotron frequency is 13.56 MHz. This is roughly ten times the nominal value $B_E = .5$ Gauss of the Earth's magnetic field and 24 times the value of dark magnetic field $B_d = .4B_E = .2$ Gauss needed to explain the effects of ELF em fields on vertebrate brain. Maybe dark matter at flux tubes of Earth's magnetic field with Planck constant equal to $\hbar/\hbar_0 = \frac{1}{4}\frac{E}{E_{rf}}$ transforms radio frequency photons to dark photons or induces resonantly the generation of cyclotron photons, which in turn leak out from magnetic flux tubes and form ordinary photons inducing the burning of water. $E_\gamma = .4$ eV would give $\hbar/\hbar_0 == 1.063 \times 2^{21}$ and $E_\gamma = .36$ eV would give $\hbar/\hbar_0 = .920 \times 2^{21}$.

3. Magnetic fields of magnitude.2 Gauss are in central role in TGD based model of living matter and there are excellent reasons to expect that this mechanism could be involved also with processes involved with living matter. There is indeed evidence for this. The experiments of Gariaev demonstrated that the irradiation of DNA with 2 eV laser photons (which correspond to one particular metabolic energy quantum) induced generation of radio wave photons having unexpected effects on living matter (enhanced metabolic activity) [I4], and that even a realization of genetic code in terms of the time variation of polarization direction could be involved. TGD based model [K5, K35] identifies radio-wave photons as dark photons with same energy as possessed by incoming visible photons so that a transformation of ordinary photons to dark photons would have been in question. The model assumed hierarchy of values of magnetic fields in accordance with the idea about onion like structure of the magnetic body.

There are several questions to be answered.

1. Is there some trivial explanation for why salt must be present or is new physics involved also here. What comes in mind are Cooper pairs dark Na^+ ions (or their exotic counterparts which are bosons) carrying Josephson currents through the cell membrane in the model of the cell membrane as a Josephson junction which is almost vacuum extremal of Kähler action. In the experimental arrangement leading to the generation of exclusion zones the pH of water was important control factor, and it might be that the presence of salt has an analogous role to that of protons.

2. Does this effect occur also for solutions of other molecules and other solutes than water? This can be tested since the rotational spectra are readily calculable from data which can be found at net.

3. Are the radio wave photons dark or does water - which is very special kind of liquid - induce the transformation of ordinary radio wave photons to dark photons by fusing $r = \hbar/\hbar_0$ radio wave massless extremals (MEs) to single ME. Does this transformation occur for all frequencies? This kind of transformation might play a key role in transforming ordinary EEG photons to dark photons and partially explain the special role of water in living systems.

4. Why the radiation does not induce spontaneous combustion of living matter which contains salt. And why cancer cells seem to burn: is salt concentration higher inside them? As a matter fact, there are reports about [D10]. One might hope that there is a mechanism inhibiting this since otherwise military would be soon developing new horror weapons unless it is doing this already now. Is it that most of salt is ionized to Na^+ and Cl^- ions so that spontaneous combustion can be avoided? And how this relates to the sensation of spontaneous burning [D9] - a very painful sensation that some part of body is burning?

5. Is the energy heating solely due to rotational excitations? It might be that also a "dropping" of ions to larger space-time sheets is induced by the process and liberates zero point kinetic energy. The dropping of proton from k=137 (k=139) atomic space-time sheet liberates about.5 eV (0.125 eV). The measured temperature corresponds to the energy.15 eV. This dropping is an essential element in the ealier of remote metabolism and provides universal metabolic energy quanta. It is also involved with TGD based models of "free energy" phenomena. No perpetuum mobile is predicted since there must be a mechanism driving the dropped ions back to the original space-time sheets.

   In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated.

6. The electrolysis of water and also cavitation produces what is known as Brown's gas which should consist of water vapour and there might be a connection to the burning of salt water. The properties of Brown's gas [H3] however do not support this interpretation: for instance, Brown's gas has temperature of about 130 C but is able to melt metals so that some un-known mechanism liberating energy must be involved explaining also the claims about over-unity energy production in water splitting using electrolysis. TGD inspired model for Brown's gas [K19] suggests that activated water and Brown's gas correspond to same phase involving polymer sequences formed from exotic water molecules for which one hydrogen nucleus is dark and defining the analogs of basic biopolymers. The bond binding protons to a polymer like sequence would serve as the counterpart of covalent bond.

   One also ends up with a more detailed TGD inspired view about basic mechanism of metabolism in living matter predicting a tight correlation between p-adic length scale hypothesis and hierarchy of Planck constants. The model differs in some aspects from the rough models considered hitherto assuming that metabolic energy is liberated as zero point kinetic energy when particle drops to a larger space-time sheet or as cyclotron energy when cyclotron quantum number decreases. Now a phase transition increasing the p-adic length scale of the space-time surface would liberate either kinetic energy of cyclotron energy. Quantum numbers would not change: rather, t the scale appearing as a parameter in the expression of kinetic or cyclotron energy would change adiabatically and in this manner guarantee coherence. Also a phase transition in which the changes of scale due to a reduction of Planck constant and increase of the p-adic length scale compensate each other liberate metabolic energy.

Recall that one of the empirical motivations for the hierarchy of Planck constants came from the observed quantum like effects of ELF em fields at EEG frequencies on vertebrate brain and also from the correlation of EEG with brain function and contents of consciousness difficult to understand since the energies of EEG photons are ridiculously small and should be masked by thermal noise.

7 Connection With Mono-Atomic Elements, Cold Fusion, And Sono-luminescence?

Anomalies are treasures for a theoretician and during years I have been using quite a bundle of reported anomalies challenging the standard physics as a test bed for the TGD vision about physics. The so called mono-atomic elements, cold fusion, and sonofusion represent examples of this kind of anomalies not taken seriously by most standard physicists. In the following the possibility that dark matter as large $\hbar$ phase could allow to understand these anomalies.

Of course, I hear the angry voice of the skeptic reader blaming me for a complete lack of source criticism and the skeptic reader is right. I however want to tell him that I am not a soldier in troops of either skeptics or new-agers. My attitude is "let us for a moment assume that these findings are real..." and look for the consequences in this particular theoretical framework.

7.1 Mono-Atomic Elements As Dark Matter And High T_c Super-Conductors?

The ideas related to many-sheeted space-time began to develop for a decade ago. The stimulation came from a contact by Barry Carter who told me about so called mono-atomic elements, typically transition metals (precious metals), including Gold. According to the reports these elements, which are also called ORMEs ("orbitally rearranged monoatomic elements") or ORMUS, have following properties.

1. ORMEs were discovered and patented by David [H1] [H1] are peculiar elements belonging to platinum group (platinum, palladium, rhodium, iridium, ruthenium and osmium) and to transition elements (gold, silver, copper, cobalt and nickel).

2. Instead of behaving as metals with valence bonds, ORMEs have ceramic like behavior. Their density is claimed to be much lower than the density of the metallic form.

3. They are chemically inert and poor conductors of heat and electricity. The chemical inertness of these elements have made their chemical identification very difficult.

4. One signature is the infra red line with energy of order .05 eV. There is no text book explanation for this behavior. Hudson also reports that these elements became visible in emission spectroscopy in which elements are posed in strong electric field after time which was 6 times longer than usually.

The pioneering observations of David Hudson [H1] - if taken seriously - suggest an interpretation as an exotic super-conductor at room temperature having extremely low critical magnetic fields of order of magnetic field of Earth, which of course is in conflict with the standard wisdom about super-conductivity. After a decade and with an impulse coming from a different contact related to ORMEs, I decided to take a fresh look on Hudson's description for how he discovered ORMEs [H1] with dark matter in my mind. From experience I can tell that the model to be proposed is probably not the final one but it is certainly the simplest one.

There are of course endless variety of models one can imagine and one must somehow constrain the choices. The key constraints used are following.

1. Only valence electrons determining the chemical properties appear in dark state and the model must be consistent with the general model of the enhanced conductivity of DNA assumed to be caused by large $\hbar$ valence electrons with $r = \hbar/\hbar_0 = n$, $n = 5, 6$ assignable with aromatic rings. $r = 6$ for valence electrons would explain the report of Hudson about anomalous emission spectroscopy.

2. This model cannot explain all data. If ORMEs are assumed to represent very simple form of living matter also the presence electrons having $\hbar/\hbar_0 = 2^{k11}$, $k = 1$, can be considered and would be associated with high T_c super-conductors whose model predicts structures with thickness of cell membrane. This would explain the claims about very low critical magnetic fields destroying the claimed superconductivity.

Below I reproduce Hudson's own description here in a somewhat shortened form and emphasize that must not forget professional skepticism concerning the claimed findings.

Table 2: Boiling temperatures of elements appearing in the samples of Hudson.

Element	Ca	Fe	Si	Al	Pd	Rh
$T_B/^oC$	1420	1535	2355	2327	>2200	2500
Element	Ru	Pt	Ir	Os	Ag	Au
$T_B/^oC$	4150	4300	> 4800	> 5300	1950	2600

7.1.1 Basic findings of Hudson

Hudson was recovering gold and silver from old mining sources. Hudson had learned that something strange was going on with his samples. In molten lead the gold and silver recovered but when "I held the lead down, I had nothing". Hudson tells that mining community refers to this as "ghost-gold", a non-assayable, non-identifiable form of gold.

Then Hudson decided to study the strange samples using emission spectroscopy. The sample is put between carbon electrodes and arc between them ionizes elements in the sample so that they radiate at specific frequencies serving as their signatures. The analysis lasts 10-15 seconds since for longer times lower electrode is burned away. The sample was identified as Iron, Silicon, and Aluminium. Hudson spent years to eliminate Fe, Si, and Al. Also other methods such as Cummings Microscopy, Diffraction Microscopy, and Fluorescent Microscopy were applied and the final conclusion was that there was nothing left in the sample in spectroscopic sense.

After this Hudson returned to emission spectroscopy but lengthened the time of exposure to electric field by surrounding the lower Carbon electrode with Argon gas so that it could not burn. This allowed to reach exposure times up to 300 s. The sample was silent up to 90 s after which emission lines of Palladium (Pd) appeared; after 110 seconds Platinum (Pt); at 130 seconds Ruthenium (Ru); at about 140-150 seconds Rhodium; at 190 seconds Iridium; and at 220 seconds Osmium appeared. This is known as fractional vaporization.

Hudson reports the boiling temperatures for the metals in the sample having in mind the idea that the emission begins when the temperature of the sample reaches boiling temperature inspired by the observation that elements become visible in the order which is same as that for boiling temperatures.

The boiling temperatures for the elements appearing in the sample are given by **Table 2**.

Hudson experimented also with commercially available samples of precious metals and found that the lines appear within 15 seconds, then follows a silence until lines re-appear after 90 seconds. Note that the ratio of these time scales is 6. The presence of some exotic form of these metals suggests itself: Hudson talks about mono-atomic elements.

Hudson studied specifically what he calls mono-atomic gold and claims that it does not possess metallic properties. Hudson reports that the weight of mono-atomic gold, which appears as a white powder, is 4/9 of the weight of metallic gold. Mono-atomic gold is claimed to behave like super-conductor.

Hudson does not give a convincing justification for why his elements should be mono-atomic so that in following this attribute will be used just because it represents established convention. Hudson also claims that the nuclei of mono-atomic elements are in a high spin state. I do not understand the motivations for this statement.

7.1.2 Claims of Hudson about ORMEs as super conductors

The claims of Hudson that ORMES are super conductors [H1] are in conflict with the conventional wisdom about super conductors.

1. The first claim is that ORMEs are super conductors with gap energy about $E_g = .05$ eV and identifies photons with this energy resulting from the formation of Cooper pairs. This energy happens to correspond one of the absorption lines in high T_c superconductors.

2. ORMEs are claimed to be super conductors of type II with critical fields H_{c1} and H_{c2} of order of Earth's magnetic field having the nominal value $.5 \times 10^{-4}$ Tesla [H1]. The estimates

for the critical parameters for the ordinary super conductors suggests for electronic super conductors critical fields, which are about .1 Tesla and thus by a factor $\sim 2^{12}$ larger than the critical fields claimed by Hudson.

3. It is claimed that ORME particles can levitate even in Earth's magnetic field. The latter claim looks at first completely nonsensical. The point is that the force giving rise to the levitation is roughly the gradient of the would-be magnetic energy in the volume of levitating super conductor. The gradient of average magnetic field of Earth is of order B/R, R the radius of Earth and thus extremely small so that genuine levitation cannot be in question.

7.1.3 Minimal model

Consider now a possible TGD inspired model for these findings assuming for definiteness that the basic Hudson's claims are literally true.

1. In what sense mono-atomic elements could be dark matter?

The simplest option suggested by the applicability of emission spectroscopy and chemical inertness is that mono-atomic elements correspond to ordinary atoms for which valence electrons are dark electrons with large value of $r = \hbar/\hbar_0$. Suppose that the emission spectroscopy measures the energies of dark photons from the transitions of dark electrons transforming to ordinary photons before the detection by de-coherence increasing the frequency by r. The size of dark electrons and temporal duration of basic processes would be zoomed up by r.

Since the time scale after which emission begins is scaled up by a factor 6, there is a temptation to conclude that $r = 6$ holds true. Note that $n = 6$ corresponds to Fermat polygon and is thus preferred number theoretically in TGD based model for preferred values of $\hbar$ [K12]. The simplest possibility is that the group G_b is trivial group and $G_a = A_6$ or D_6 so that ring like structures containing six dark atoms are suggestive.

This brings in mind the model explaining the anomalous conductivity of DNA by large $\hbar$ valence electrons of aromatic rings of DNA. The zooming up of spatial sizes might make possible exotic effects and perhaps even a formation of atomic Bose-Einstein condensates of Cooper pairs. Note however that in case of DNA $r = 6$ not gives only rise to conductivity but not super-conductivity and that $r = 6$ cannot explain the claimed very low critical magnetic field destroying the super-conductivity.

2. Loss of weight

The claimed loss of weight by a factor $p \simeq 4/9$ is a very significant hint if taken seriously. The proposed model implies that the density of the partially dark phase is different from that of the ordinary phase but is not quantitative enough to predict the value of p. The most plausible reason for the loss of weight would be the reduction of density induced by the replacement of ordinary chemistry with $r = 6$ chemistry for which the Compton length of valence electrons would increase by this factor.

3. Is super-conductivity possible?

The overlap criterion is favorable for super-conductivity since electron Compton lengths would be scaled up by factor $n_a = 6, n_b = 1$. For $r = \hbar/\hbar_0 = n_a = 6$ Fermi energy would be scaled up by $n_a^2 = 36$ and if the same occurs for the gap energy, T_c would increase by a factor 36 from that predicted by the standard BCS theory. Scaled up conventional super-conductor having $T_c \sim 10$ K would be in question (conventional super-conductors have critical temperatures below 20 K). 20 K upper bound for the critical temperature of these superconductors would allow 660 K critical temperature for their dark variants!

For large enough values of r the formation of Cooper pairs could be favored by the thermal instability of valence electrons. The binding energies would behave as $E = r^2 Z_{eff}^2 E_0/n^2$, where Z_{eff} is the screened nuclear charge seen by valence electrons, n the principal quantum number for the valence electron, and E_0 the ground state energy of hydrogen atom. This gives binding energy smaller than thermal energy at room temperature for $r > (Z_{eff}/n)\sqrt{2E_0/3T_{room}} \simeq 17.4 \times (Z_{eff}/n)$. For $n = 5$ and $Z_{eff} < 1.7$ this would give thermal instability for $r = 6$.

Interestingly, the reported .05 eV infrared line corresponds to the energy assignable to cell membrane voltage at criticality against nerve pulse generation, which suggests a possible connection

with high T_c superconductors for which also this line appears and is identified in terms of Josephson energy. .05 eV line appears also in high T_c superconductors. This interpretation does not exclude the interpretation as gap energy. The gap energy of the corresponding BCS super-conductor would be scaled down by $1/r^2$ and would correspond to 14 K temperature for $r = 6$.

Also high T_c super-conductivity could involve the transformation of nuclei at the stripes containing the holes to dark matter and the formation of Cooper pairs could be due to the thermal instability of valence electrons of Cu atoms (having $n = 4$). The rough extrapolation for the critical temperature for cuprate superconductor would be $T_c(Cu) = (n_{Cu}/n_{Rh})^2 T_c(Rh) = (25/36)T_c(Rh)$. For $T_c(Rh) = 300$ K this would give $T_c(Cu) = 192$ K: according to Wikipedia cuprate perovskite has the highest known critical temperature which is 138 K. Note that quantum criticality suggests the possibility of several values of (n_a, n_b) so that several kinds of super-conductivities might be present.

7.1.4 ORMEs as partially dark matter, high T_c super conductors, and high T_c superfluids

The appearance of .05 eV photon line suggest that same phenomena could be associated with ORMEs and high T_c super-conductors. The strongest conclusion would be that ORMEs are T_c super-conductors and that the only difference is that Cu having single valence electron is replaced by a heavier atom with single valence electron. In the following I shall discuss this option rather independently from the minimal model.

1. ORME super-conductivity as quantum critical high T_c superconductivity

ORMEs are claimed to be high T_c superconductors and the identification as quantum critical superconductors seems to make sense.

1. According to the model of high T_c superconductors as quantum critical systems, the properties of Cooper pairs should be more or less universal so that the observed absorption lines discussed in the section about high T_c superconductors should characterize also ORMEs. Indeed, the reported 50 meV photon line corresponds to a poorly understood absorption line in the case of high T_c cuprate super conductors having in TGD framework an interpretation as a transition in which exotic Cooper pair is excited to a higher energy state. Also Copper is a transition metal and is one of the most important trace elements in living systems [D2]. Thus the Cooper pairs could be identical in both cases. ORMEs are claimed to be superconductors of type II and quantum critical superconductors are predicted to be of type II under rather general conditions.

2. The claimed extremely low value of H_c is also consistent with the high T_c superconductivity. The supra currents in the interior of flux tubes of radius of order $L_w = .4$ μm are BCS type supra currents with large $\hbar$ so that T_c is by a factor 2^{14} ($127 - 113 = 14$ is inspired by the Mersenne hypothesis for the preferred p-adic length scales) higher than expected and H_c is reduced by a factor 2^{-10}. This indeed predicts the claimed order of magnitude for the critical magnetic field.

3. The problem is that $r = 2^{14}$ is considerably higher that $r = 6$ suggested by the minimum model explaining the emission spectroscopic results of Hudson. Of course, several values of $\hbar$ are possible so that internal consistency would be achieved if ORMEs are regarded as a very simple form of living matter with relatively small value of r and giving up the claim about the low value of critical magnetic field.

4. The electronic configurations of Cu and Gold are chemically similar. Gold has electronic configuration $[Xe, 4f^{14}5d^{10}]6s$ with one valence electron in s state whereas Copper corresponds to $3d^{10}4s$ ground state configuration with one valence electron. This encourages to think that the doping by holes needed to achieve superconductivity induces the dropping of these electrons to $k = 151$ space-time sheets and gives rise to exotic Cooper pairs.

   In many-sheeted space-time particles topologically condense at all space-time sheets having projection to given region of space-time so that this option makes sense only near the boundaries of space-time sheet of a given system. Also p-adic phase transition increasing the

size of the space-time sheet could take place and the liberated energy would correspond to the reduction of zero point kinetic energy. Particles could be transferred from a portion of magnetic flux tube portion to another one with different value of magnetic field and possibly also of Planck constant h_{eff} so that cyclotron energy would be liberated.

Also this model assumes the phase transition of some fraction of Cu nuclei to large $\hbar$ phase and that exotic Cooper pairs appear at the boundary of ordinary and large $\hbar$ phase.

More generally, elements having one electron in s state plus full electronic shells are good candidates for doped high T_c superconductors. Both Cu and Au atoms are bosons. More generally, if the atom in question is boson, the formation of atomic Bose-Einstein condensates at Cooper pair space-time sheets is favored. Thus elements with odd value of A and Z possessing full shells plus single s wave valence electron are of special interest. The six stable elements satisfying these conditions are ^{5}Li, ^{39}K, ^{63}Cu, ^{85}Rb, ^{133}Cs, and ^{197}Au.

2. "Levitation" and loss of weight

The model of high T_c superconductivity predicts that some fraction of Cu atoms drops to the flux tube with radius $L_w = .4$ μm and behaves as a dark matter. This is expected to occur also in the case of other transition metals such as Gold. The atomic nuclei at this space-time sheet have high charges and make phase transition to large $\hbar$ phase and form Bose-Einstein condensate and superfluid behavior results. Electrons in turn form large $\hbar$ variant of BCS type superconductor. These flux tubes are predicted to be negatively charged because of the Bose-Einstein condensate of exotic Cooper pairs at the boundaries of the flux tubes having thickness $L(151)$. The average charge density equals to the doping fraction times the density of Copper atoms.

The first explanation would be in terms of super-fluid behavior completely analogous to the ability of ordinary superfluids to defy gravity. Second explanation is based on the electric field of Earth which causes an upwards directed force on negatively charged BE condensate of exotic Cooper pairs and this force could explain both the apparent levitation and partial loss of weight. The criterion for levitation is $F_e = 2eE/x \geq F_{gr} = Am_pg$, where $g \simeq 10$ m^2/s is gravitational acceleration at the surface of Earth, A is the atomic weight and m_p proton mass, E the strength of electric field, and x is the number of atoms at the space-time sheet of a given Cooper pair. The condition gives $E \geq 5 \times 10{-}10Ax$ V/m to be compared with the strength $E = 10^2 - 10^4$ V/m of the Earths electric field.

An objection against the explanation for the effective loss of weight is that it depends on the strength of electric field which varies in a wide range whereas Hudson claims that the reduction factor is constant and equal to 4/9. A more mundane explanation would be in terms of a lower density of dark Gold. This explanation is quite plausible since there is no atomic lattice structure since nuclei and electrons form their own large $\hbar$ phases.

4. The effects on biological systems

Some monoatomic elements such as White Gold are claimed to have beneficial effects on living systems [H1]. 5 per cent of brain tissue of pig by dry matter weight is claimed to be Rhodium and Iridium. Cancer cells are claimed to be transformed to healthy ones in presence of ORMEs. The model for high T_c super conductivity predicts that the flux tubes along which interior and boundary supra currents flow has same structure as neuronal axons. Even the basic length scales are very precisely the same. On basis of above considerations ORMEs are reasonable candidates for high T_c superconductors and perhaps even super fluids.

The common mechanism for high T_c, ORME- and bio- super-conductivities could explain the biological effects of ORMEs.

1. In unhealthy state superconductivity might fail at the level of cell membrane, at the level of DNA or in some longer length scales and would mean that cancer cells are not anymore able to communicate. A possible reason for a lost super conductivity or anomalously weak super conductivity is that the fraction of ORME atoms is for some reason too small in unhealthy tissue.

2. The presence of ORMEs could enhance the electronic bio- superconductivity which for some reason is not fully intact. For instance, if the lipid layers of cell membrane are, not only

wormhole-, but also electronic super conductors and cancer involves the loss of electronic super-conductivity then the effect of ORMEs would be to increase the number density of Cooper pairs and make the cell membrane super conductor again. Similar mechanism might work at DNA level if DNA: s are super conductors in "active" state.

5. Is ORME super-conductivity associated with the magnetic flux tubes of dark magnetic field $B_d = 0.2$ Gauss?

The general model for the ionic super-conductivity in living matter, which has developed gradually during the last few years and will be discussed in detail later, was originally based on the assumption that super-conducting particles reside at the super-conducting magnetic flux tubes of Earth's magnetic field with the nominal value $B_E = .5$ Gauss. It became later clear that the explanation of ELF em fields on vertebrate brain requires $B_d = .2$ Gauss rather than $B_E = .5$ Gauss [K9]. The interpretation was as dark magnetic field $B_d = .2$ Gauss. The model of EEG led also to the hypothesis that Mersenne primes and their Gaussian counterparts define preferred p-adic length scales and their dark counterparts. This hypothesis replaced the earlier $r = 2^{11k}$ hypothesis.

For $r = 2^{127-113=14}$ the predicted radius $L_w = .4$ μm is consistent with the radius of neuronal axons. If one assumes that the radii of flux tubes are given by this length scale irrespective of the value of r, one must replace the quantization condition for the magnetic flux with a more general condition in which the magnetic flux is compensated by the contribution of the supra current flowing around the flux tube: $\oint (p - eA) \cdot dl = n\hbar$ and assume $n = 0$. The supra currents would be present inside living organism but in the faraway region where flux quanta from organism fuse together, the quantization conditions $e \int B \cdot dS = n\hbar$ would be satisfied.

The most natural interpretation would be that these flux tubes topologically condense at the flux tubes of B_E. Both bosonic ions and the Cooper pairs of electrons or of fermionic ions can act as charge carriers so that actually an entire zoo of super-conductors is predicted. There is even some support for the view that even molecules and macromolecules can drop to the magnetic flux tubes [K18].

7.1.5 Nuclear physics anomalies and ORMEs

At the homepage of Joe Champion [H4] information about claimed nuclear physics anomalies can be found.

1) The first anomaly is the claimed low temperature cold fusion. For instance, Champion claims that Mercury (Z=80), decays by emission of proton and neutrons to Gold with Z=79 in the electrochemical arrangement described in [H4].

2) Champion mentions also the anomalous production of Cadmium isotopes electrochemically in presence of Palladium reported by Tadahiko Mizuno.

The simplest explanation of the anomalies would be based on genuine nuclear reactions. The interaction of dark nuclei with ordinary nuclei at the boundary between the two phases would make possible genuine nuclear transmutations since the Coulomb wall hindering usually cold fusion and nuclear transmutations would be absent (Trojan horse mechanism). Both cold fusion and reported nuclear transmutations in living matter could rely on this mechanism as suggested in [K32, L2, K8], [L2].

7.1.6 Possible implications

The existence of exotic atoms could have far reaching consequences for the understanding of bio-systems. If Hudson's claims about super-conductor like behavior are correct, the formation of exotic atoms in bio-systems could provide the needed mechanism of electronic super-conductivity. One could even argue that the formation of exotic atoms is the magic step transforming chemical evolution to biological evolution.

Equally exciting are the technological prospects. If the concept works it could be possible to manufacture exotic atoms and build room temperature super conductors and perhaps even artificial life some day. It is very probable that the process of dropping electron to the larger space-time sheet requires energy and external energy feed is necessary for the creation of artificial life. Otherwise the Earth and other planets probably have developed silicon based life for long time

ago. Ca, K and Na ions have central position in the electrochemistry of cell membranes. They could actually correspond to exotic ions obtained by dropping some valence electrons from $k = 137$ atomic space-time sheet to larger space-time sheets. For instance, the $k = 149$ space-time sheet of lipid layers could be in question.

The status of ORMEs is far from certain and their explanation in terms of exotic atomic concept need not be correct. The fact is however that TGD predicts exotic atoms: if they are not observed TGD approach faces the challenge of finding a good explanation for their non-observability.

Interestingly, Palladium is one of the "mono-atomic" elements used also in cold fusion experiments as a target material [C6, C18]. This inspires the question whether mono-atomic phase is one of the prerequisites for cold fusion.

7.2 Basic Ideas About Cold Fusion

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

7.2.1 What makes possible cold fusion?

I have proposed that cold fusion might be based on Trojan horse mechanism in which incoming and target nuclei feed their em gauge fluxes to different space-time sheets so that electromagnetic Coulomb wall disappears [K32]. If part of Palladium nuclei are "partially dark", this is achieved. Another mechanism could be the de-localization of protons to a larger volume than nuclear volume induced by the increase of h_{eff} meaning that reaction environment would differ dramatically from that appearing in the usual nuclear reactions and the standard objections against cold fusion would not apply anymore [K32]: this de-localization could correspond to the darkness of electromagnetic and perhaps also electroweak field bodies of protons.

A third proposal is perhaps the most elegant and relies on the nuclear string model [L2] predicting a large number of exotic nuclei obtained by allowing the color bonds connecting nucleons to have all possible em charges $1, 0, 1$. Many ordinary heavy nuclei would be exotic in the sense that some protons would correspond to protons plus negatively charged color bonds. The exchange of an exotic weak boson between D and Pd nuclei transforming D nuclei to exotic neutral D nuclei would occur. The range of the exotic weak interaction correspond to atomic length scale meaning that it behaves as massless particle below this length scale. For instance, W boson could be $r = 2^{24}$ dark variant of $k = 113$ weak boson for which the dark variant of p-adic scale would correspond to the atomic scale $k = 137$ but also other options are possible.

7.2.2 How standard objections against cold fusion can be circumvented?

The following arguments against cold fusion are from an excellent review article by Storms [C7].

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

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

3. When such an energy is released under normal conditions, energetic particles are emitted along with various kinds of radiation, only a few of which are seen by various CANR (Chemically Assisted Nuclear Reactions) studies. In addition, gamma emission must accompany helium, and production of neutrons and tritium, in equal amounts, must result from any fusion reaction. None of these conditions is observed during the claimed CANR effect, no

matter how carefully or how often they have been sought. The large value of $\hbar(M^4)$ implying large Compton lengths for protons making possible geometric coupling of gamma rays to condensed matter would imply that gamma rays do not leave the system. If only protons form the quantum coherent state then fusion reactions do not involve the protons of the catode at all and production of ^3He and thus of neutrons in the fusion of D and exotic D.

4. The claimed nuclear transmutation reactions (reported to occur also in living matter [C5]) are very difficult to understand in standard nuclear physics framework.

   (a) The model of [K32] allows them since protons of different nuclei can re-arrange in many different manners when the dark matter state decays back to normal.

   (b) Nuclear string model [L2] allows transmutations too. For instance, neutral exotic tritium produced in the reactions can fuse with Pd and other nuclei.

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

7.2.3 Mechanisms of cold fusion

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

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

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

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

From this it is clear that it easy to invent models consistent with observations: careful consideration of data might however allow to fix the model to a high degree. One can try to deduce a more detailed model for cold fusion from observations, which are discussed systematically in [C7] and in the references discussed therein.

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

   (a) These findings are consistent the view that patches correspond to a macroscopic quantum phase involving de-localized nuclear protons. The added ordinary protons and fractures could serve as a seed for a phase transition leading to the ordinary phase [K32].

   (b) An alternative interpretation is in terms of the formation of neutral exotic D and exotic Pd via exchange of exotic, possibly dark, W bosons massless below atomic length scale [L2].

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

For ordinary nuclei fusions to tritium and ^3He occur with approximately identical rates. The first reaction produces neutron and ^3He via $D + D \to n +^3 He$, whereas second reaction produces proton and tritium by $3H$ via $D + D \to p +^3 H$. The prediction is that one neutron per each tritium nucleus should be produced. Tritium can be observed by its beta decay to ^3He and neutron flux is several orders of magnitude smaller than tritium flux as found for instance by Tadahiko Mizuno and his collaborators (Mizuno describes the experimental process leading to this discovery in his book [C11]). Hence the reaction producing ^3He cannot occur significantly in cold fusion which means a conflict with the basic predictions of the standard nuclear physics.

(a) The explanation discussed in [K32] does not involve exotic nuclei with charged color bonds. The assumption is that the proton in the target deuterium $\hat{D}$ is in the exotic state with large Compton length and the production of ^3He occurs very slowly since $\hat{p}$ and p correspond to different space-time sheets. Since neutrons and the proton of the D from the electrolyte are in the ordinary state, Coulomb barrier is absent and tritium production can occur. The mechanism also explains why the cold fusion producing ^3He and neutrons does not occur using water instead of heavy water.

(b) Nuclear string model [L2] model with charged color bonds predicts that only neutral exotic tritium is produced considerably when incoming deuterium interacts with neutral exotic deuterium in the target. This requires that in target D nuclei exchange large $\hbar$ W boson with electron or Pd or other D nucleus. In the latter case the outcome is two exotic nuclei looking chemically like di-neutron and ^3He.

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

   (a) ^4He can be produced in reactions such as $D + \hat{D} \to^4 He$ or its exotic counterpart in the model of [K32].

   (b) Nuclear string model [K32] does not allow direct production of ^4He in D-D collisions.

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

   Both models allow nuclear transmutations. In nuclear string model [K32] the resulting exotic tritium can fuse with Pd and other nuclei and produce nuclear transmutations.

   The reported occurrence of nuclear transmutation such as $^{23}Na +^{16} O \to^{39} K$ in living matter [C5] allowing growing cells to regenerate elements K, Mg, Ca, or Fe, could be understood in nuclear string model if also neutral exotic charge states are possible for nuclei in living matter. The experimental signature for the exotic ions would be cyclotron energy spectrum containing besides the standard lines also lines with ions with anomalous mass number. This could be seen as a splitting of lines. For instance, exotic variants of ions such Na^+, K^+, Cl^-, Ca^{++} with anomalous mass numbers should exist. It would be easy to mis-interpret the situation unless the actual strength of the magnetic field is not checked.

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

   (a) The explanation of the model of [K32] is that the recoil momentum goes to the macroscopic quantum phase and eventually heats the electrolyte system. This provides obviously the mechanism by which the liberated nuclear energy is transferred to the electrolyte difficult to imagine in standard nuclear physics framework. The emitted gamma rays could be also dark and observed only if they transform to ordinary ones.

   (b) In nuclear string model [L2] ^4He is not produced at all.

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

(a) In the model of [K32] (no charged color bonds) a possible mechanism is the production of neutrons in the phase transition $\hat{p} \to p$. $\hat{D} \to p + n$ could occur as the proton contracts back to the ordinary size in such a manner that it misses the neutron. This however requires energy of 2.23 MeV if the rest masses of $\hat{D}$ and D are same. Also $\hat{D} + \hat{D} \to n +^3 He$ could be induced by the phase transition to ordinary matter when $\hat{p}$ transformed to p does not combine with its previous neutron partner to form D but recombines with $\hat{D}$ to form $^3\hat{H}e \to^3 He$ so that a free neutron is left.

(b) Nuclear string model [L2] would suggest that the collisions of protons of water with exotic neutral D with negatively charged color bond produce neutron and ordinary D. This requires the transformation of negatively charged color bond between p and n of target D to a neutral color bond between incoming p and neutron of target.

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

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

Lubos Motl has been raging several times about the cold fusion gadget of Andrea Rossi and I decided to write the following response as he returned to the topic again (see `http://tinyurl.com/ot5kfok`). The claim of Rossi and physicist Fogardi [C15] is that the cold fusion reaction of H and Ni producing Cu takes place in the presence of some "additives" (Palladium catalyst as in may cold fusion experiments gathering at its surface Ni?).

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

Lubos Motl of course "knows" before hand that the gadget cannot work: Coulomb barrier. Since Lubos Motl is true believer in naive text book wisdom, he simply refuses to consider the possibility that the physics that we learned during student days might not be quite right. Personally I do not believe or disbelieve cold fusion: I just take it seriously as any person calling himself scientist should do. I have been developing for more than 15 years ideas about possible explanation of cold fusion in TGD framework. The most convincing idea is that large value of Planck constant associated with nuclei could be involved scaling up the range of weak interactions from 10^{-17} meters to atomic size scale and also scaling up the size of nucleus to atomic size scale so that nucleus and even quarks would like constant charge densities instead of point like charge. Therefore Coulomb potential would be smoothed and the wall would become much lower [K32, L2].

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

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

science what jesuits were for the catholic church. Indeed, as Loyola said: the purpose sanctifies the deeds.

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

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

   Comments:

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

   (b) This is only one particular demonstration and it might be that there are other demonstrations in which the situation is this. As a matter fact, from an excellent video interview of Nobelist Brian Josephson (see `http://tinyurl.com/ya2n6mbd`) one learns that there are also demonstrations in which water is only heated so that the argument of Lubos Motl does not bite here. The gadget of Rossi is already used to heat university building. The reason why the evaporation is probably that this provides an effective manner to collect the produced energy. Also by reading the Nyteknik report (see `http://tinyurl.com/ohal8cd`) [C15] one learns that the energy production is directly measured rather than being based on the assumption that evaporation occurs.

2. Is the water evaporated or not? This is the question posed by Lubos Motl. The demonstration shows explicitly that there is a flow of vapor from the outlet. As Rossi explains there is some condensation. Lubos Motl claims that the flow of about 2 liters of vapor per second resulting from the evaporation 2 ml of water per second should produce much more dramatic visual effect. More vapor and with a faster flow velocity. Lubos Motl claims that water just drops from the tube and part of it spontaneously evaporates. This is what Lubos Motl wants to see and I have no doubt that he is seeing it. Strong belief can move mountains! Or at least can make possible the impression that they are moving!

   Comments:

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

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

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

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

A possible concrete model relies on the generation of large h_{eff} variants of weak bosons effectively massless below the dark weak scale, which relates to the weak scale by a factor h_{eff}/h or $(h_{eff}/h)^{1/2}$ (depending on whether the p-adic length scale is proportional to h_{eff} as suggested by the definition of Compton length or to $(h_{eff}/h)^{1/2}$ as suggested by p-adic mass calculations). In any case case, the weak scale would be scaled down from about 10^{-17} meters to atomic length scale 10^{-10} meters. This would make weak interactions as strong as em interaction below dark weak scale and proton could exchange dark W boson with target nucleus transforming therefore to neutron experiencing no Coulomb wall. Dark weak boson would be absorbed by color bond between nuclei of nuclear string [L2].

To sum up, Lubos Motl in his eagerness to debunk forgets that he is concentrating on single demonstration and forgetting other demonstrations altogether and also the published report [C15] to which his argument do not apply. I remain however skeptic (I mean real skeptic, the skepticism of Lubos Motl and -sad to say- of quite too many skeptics- has nothing to do with a real skeptic attitude). Rossi should give information about the details of his invention and quantitative tests really measuring the heat produced should be carried out and published. Presumably the financial aspects related to the invention explain the secrecy in a situation in which patenting is difficult.

7.3.2 Objections from nuclear physics

The reading of Rossi's paper and Wikipedia article led me to consider in more detail also various nuclear physics based objections (see `http://tinyurl.com/yd8wka4w`) against Rossi's reactor [C3]. Coulomb barrier, the lack of gamma rays, the lack of explanation for the origin of the extra energy, the lack of the expected radioactivity after fusing a proton with ^{58}Ni (production of neutrino and positron in beta decay of ^{59}Cu), the unexplained occurrence of 11 per cent iron in the spent fuel, the 10 per cent copper in the spent fuel strangely having the same isotopic ratios as natural copper, and the lack of any unstable copper isotopes in the spent fuel as if the reactor only produced stable isotopes.

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

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

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

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

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

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

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

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

1. By inspecting stable nuclides (see `http://tinyurl.com/2etfs4m`) one learns that there are two fusion cascades. In the first cascade the isotopes of copper would be produced in a cascade starting from with $^{58}Ni + n \rightarrow^{59} Cu$ and stopping at ^{63}Cu. All isotopes ^{A}Cu, $A \in \{55, 62\}$ are unstable with lifetime shorter than one day. The second fusion cascade begins from ^{63}Ni and stops at ^{65}Cu.

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

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

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

The claimed absence of positrons from beta decays and the absence of gamma rays are strong objections against the assumption that standard nuclear physics is enough. In TGD framework it is possible to ask whether the postulated fusion cascades really occur and whether instead of it weak interactions in dark phase of nuclear matter with range of order atomic length scale are responsible for the process because weak bosons would be effectively massless below atomic length scale. For TGD inspired model of cold fusion see `http://tinyurl.com/y73ydac9` and `hhttp://tinyurl.com/zofj62f` [K32, L2].

1. The nuclear string model assumes that nucleons for nuclear strings with nucleons connected with color bonds having quark and antiquark at their ends. Color bonds could be also charged and this predicts new kind of internal structure for nuclei. Suppose that the space-time sheets mediating weak interactions between the color bonds and nucleons correspond to so large value of Planck constant that weak interaction length scale is scaled up to atomic length scale. The generalization of this hypothesis combined with the p-adic length scale hypothesis is actually standard piece of TGD inspired quantum biology (`http://tinyurl.com/y9mmqzk2`) [K8].

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

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

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

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

The presence of em radiation in keV range would be a testable basic signature of the new nuclear physics as also effects of X-ray irradiation on measured nuclear decay and reaction rates due to the fact that color bonds are excited. As a matter fact, it is known that X-ray bursts from Sun in keV range has effects on the measured nuclear decay rates and I have proposed that the proposed exotic nuclear physics in keV range is responsible for the effect. Quite generally, the excitations of color bonds would couple nuclear physics with atomic physics and I have proposed that the anomalies of water could involve classical Z^0 force in atomic length scales. Also the low compressibility of condensed matter phase could involve classical Z^0 force. The possible connections with sono-luminescence and claimed sonofusion are also obvious (`http://tinyurl.com/ycofa7jx`) [K10].

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

According to the article "Indication of anomalous heat energy production in a reactor device containing hydrogen loaded nickel powder" [H2] (`http://tinyurl.com/l22dxgk`) cold fusion has been demonstrated quite convincingly so that "indication" in the title can be take as a humorous understatement.

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

To my opinion, it seems safe to conclude that low energy nuclear reactions can be regarded as an established fact and the commercialization is indeed in full swing. It is a pity that at the same time academic theoretical physics after the results from LHC has reached dead end basically due to the sticking to the reductionistic dogma, which does not allow any new physics above elementary particle length scale - and if we believe string theorists- above Planck length length scale.

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

Sono-luminescence [D15], [D15] is a peculiar phenomenon, which might provide an application for the hydrodynamical hierarchy. The radiation pressure of a resonant sound field in a liquid can trap a small gas bubble at a velocity node. At a sufficiently high sound intensity the pulsations of the bubble are large enough to prevent its contents from dissolving in the surrounding liquid. For an air bubble in water, a still further increase in intensity causes the phenomenon of sono-luminescence above certain threshold for the sound intensity. What happens is that the minimum and maximum radii of the bubble decrease at the threshold and picosecond flash of broad band light extending well into ultraviolet is emitted. Rather remarkably, the emitted frequencies are emitted simultaneously during very short time shorter than 50 picoseconds, which suggests that the mechanism involves formation of coherent states of photons. The transition is very sensitive to external parameters such as temperature and sound field amplitude.

A plausible explanation for the sono-luminescence is in terms of the heating caused by shock waves launched from the boundary of the adiabatically contracting bubble [D15], [D15] . The temperature jump across a strong shock is proportional to the square of Mach number and increases with decreasing bubble radius. After the reflection from the minimum radius $R_s(min)$ the

outgoing shock moves into the gas previously heated by the incoming shock and the increase of the temperature after focusing is approximately given by $T/T_0 = M^4$, where M is Mach number at focusing and $T_0 \sim 300\ K$ is the temperature of the ambient liquid. The observed spectrum of sono-luminescence is explained as a brehmstrahlung radiation emitted by plasma at minimum temperature $T \sim 10^5\ K$. There is a fascinating possibility that sono-luminescence relates directly to the classical Z^0 force.

Even standard model reproduces nicely the time development of the bubble and sono-luminescence spectrum and explains sensitivity to the external parameters [D15], [D15]. The problem is to understand how the length scales are generated and explain the jump-wise transition to sono-luminescence and the decrease of the bubble radius at sono-luminescence: ordinary hydrodynamics predicts continuous increase of the bubble radius. The length scales are the ambient radius R_0 (radius of the bubble, when gas is in pressure of 1 atm) and the minimum radius $R_s(min)$ of the shock wave determining the temperature reached in shock wave heating. Zero radius is certainly not reached since shock front is susceptible to instabilities.

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

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

1. The bubble of air is characterized by its primary condensation level k. The minimum size of the bubble at level k must be larger than the electron Compton scale $L_e(k) = \sqrt{5}L(k)$. This suggests that the transition to photo-luminescence corresponds to the change in the primary condensation level of the air bubble. In the absence of photo-luminescence the level can be assumed to be $k = 163$ with $L_e(163) \sim .76\ \mu m$ in accordance with the fact that the minimum bubble radius is above $L_e(163)$. After the transition the primary condensation level of the air bubble one would have $k = 157$ with $L_e(157) \sim .07\ \mu m$. In the transition the minimum radius of the bubble decreases below $L_e(163)$ but should not decrease below $L_e(157)$: this hypothesis is consistent with the experimental data [D15], [D15].

2. The particles of hydrodynamics at level k have minimum size $L(k_{prev})$. For $k = 163$ one has $k_{prev} = 157$ and for $k = 157$ $k_{prev} = 151$ with $L_e(151) \sim 11.8\ nm$. It is natural to assume that the minimum size of the particle at level k gives also the minimum radius for the spherical shock wave since hydrodynamic approximation fails below this length scale. This means that the minimum radius of the shock wave decreases from $R_s(min, 163) = L_e(157)$ to $R_s(min, 157) = L_e(151)$ in the transition to sono-luminescence. The resulting minimum radius is 11 nm and much smaller than the radius .1 $\mu\ m$ needed to explain the observed radiation if it is emitted by plasma.

A quantitative estimate goes along lines described in [D15], [D15].

1. The radius of the spherical shock is given by

$$R_s \quad = \quad At^{\alpha} \ , \tag{7.1}$$

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

2. The collapse rate of the adiabatically compressing bubble obeys

$$\frac{dR}{dt} \quad = \quad c_0(\frac{2}{3\gamma}\frac{\rho_0}{\rho}(\frac{R_m}{R_0})^3)^{1/2} \ , \tag{7.2}$$

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

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

$$\begin{aligned} M &= \frac{\frac{dR_s}{dt}}{c_0} = (t_0/t)^{\alpha-1} \ , \\ R_s &= R_0(t/t_0)^{\alpha} \ , \\ t_0 &= \frac{\alpha R_0}{c_0} \ . \end{aligned} \tag{7.3}$$

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

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

$$\frac{T}{T_0} \simeq M^4 = (\frac{R_0}{R_s})^{\frac{4(1-\alpha)}{\alpha}} \simeq 1.3 \cdot 10^4 \ . \tag{7.4}$$

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

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

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

In TGD inspired model of cell membrane [K28] a key role is played by almost vacuum extremals for which the induced Kähler field is very small. Vacuum extremals are accompanied by a strong classical Z^0 field proportional to classical electromagnetic field and given by $Z^0 = -2\gamma/p$, $p = sin^2(\theta_W)$. One could also imagine that em field is vanishing in which case Z^0 field is proportional to Kähler field and also strong because of $Z^0 = 6J/p$, $p = sin^2(\theta_W)$ proportionality. In this case also classical color fields are present. It is however not clear whether these fields can be realized as preferred extremals of Kähler action.

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

The length scales involved correspond to Gaussian Mersennes $M_{G,k} = (1+i)^k - 1$ and together with $k = 151$ and $k = 167$ define biologically important length scales [K28]. The p-adically scaled up variants and dark variants of of QCD and weak physics have been conjectured to play key role in biology between length scales 10 nm (cell membrane thickness) and 2.5 μm (the size scale of nucleus). This motivates the question whether a nearly vacuum extremal phase (as far as induced gauge fields are considered) accompanies the transition changing the p-adic length scale associated with the bubble from $k = 163$ to $k = 157$. The acceleration in the strong Z^0 field associated with

the flux tubes could generate the visible light as brehmstrahlung radiation, perhaps also Z^0 and W bremstrahlung could be generated and would decay to photons and charged particles and generate a plasma in this manner. If the weak scale is given by $k_W = 157$, the mass scale of weak bosons is $2^{-31} \simeq 10^{-9}/2$ times smaller than that of ordinary weak bosons (about 50 eV which corresponds to a temperature of 5×10^5 K). A further transition to $k = 151$ would correspond to gauge boson mass scale 400 eV and temperature or order 4×10^6 K.

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

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

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

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

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

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

Widom and Larsen (for articles see the Widom Larsen LENR Theory Portal [C2] (see `http://tinyurl.com/boq2u2z`) have proposed a theory of cold fusion (LENR) (see `http://tinyurl.com/y8ejwxom`) [C1], which claims to predict correctly the various isotope ratios observed in cold fusion and accompanying nuclear transmutations. The ability to predict correctly the isotope ratios suggests that the model is on the right track. A further finding is that the predicted isotope ratios correspond to those appearing in Nature which suggests that LENR is perhaps more important than hot fusion in solar interior as far as nuclear abundances are considered. TGD leads to the same proposal and Lithium anomaly could be understood as one implication of LENR [L2]. The

basic step of the reaction would rely on weak interactions: the proton of hydrogen atom would transform to neutron by capturing the electron and therefore would overcome the Coulomb barrier.

8.1 Challenges Of The Model

The model has to meet several challenges.

1. The electron capture reaction $p + e \to n + \nu$ is not possible for ordinary atom since the mass difference of neutron is 1.3 MeV and larger than electron mass.5 MeV (electron has too small kinetic energy). The proposal is that strong electric fields at the catalyst surface imply renormalization effects for the plasmon phase at the surface of the catalyst increasing electron mass so that it has width of few MeVs [C24]. Physically this would mean that strong em radiation helps to overcome the kinematical threshold for the reaction. This assumption [C17]: the claim is that the mass renormalization is much smaller than claimed by Widom and Larsen.

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

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

3. The model must also explain why gamma radiation is not observed and why neutrons are produced much less than expected. Concerning gamma rays one must assume that the heavy electrons of the plasmon phase assigned to the surface of the catalyst absorb the gamma rays and re-emit them as infrared light emitted to environment as heat. Ordinary electrons cannot absorb gamma rays but heavy electrons can [C23], and the claim is that they do transform gamma rays to infrared photons. If the neutrons created in LENR have ultra-low energies their capture cross sections are enormous and the claim is that they do not get out of the system.

The assumption that electron mass is renormalized so that the capture reaction can occur but occurs only very near threshold so that the resulting neutrons are ultraslow has been criticized [C17].

8.2 TGD Variant Of The Model

TGD allows to consider two basic approaches to the LENR.

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

2. **Option II** involves involves both dark weak bosons and possibly also dark nucleons and dark electrons. The TGD inspired model for living matter - in particular, the model for cell membrane involving also Z^0 membrane potential in the case of sensory receptor neurons [K8] - favors the model involving both dark weak bosons, nucleons, and even electrons. Chiral selection for biomolecules is extremely difficult to understand in standard model but could be understood in terms of weak length scale of order atomic length scale at least: below

this scale dark weak bosons would be effectively massless and weak interactions would be as strong as em interactions. The model for electrolysis based on plasmoids identified as primitive life forms supports also this option. The presence of dark electrons is suggested by Tesla's cold currents and by the model of cell membrane.

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

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

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

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

   (b) If electron and proton are dark with $h_{eff}/h = n = 2^k$ in the range $[10^{12}, 10^{14}]$ the situation can change since W boson has its usual mass from the point of view of electron and proton. $\hbar^4/m_W^4$ factor in differential cross section for 2-to-2 scattering by W exchange is scaled up by n^4 (see the appendix of [A2] so that effectively m_W would be of order 10 keV for ordinary $\hbar$.

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

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

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

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

There are also other strange features to be understood.

1. The absence of gamma radiation could be due to the fact that the produced gamma rays are dark. For $h_{eff}/h \in [10^{12}, 10^{14}]$ the energy frequency of 1 MeV dark gamma ray would correspond to that of photon with energy of [1, .1] μeV and thus to radio wave photon with

wavelength of order 1 m and frequency of order 3×10^8 Hz. In Widom-Larsen model the photons would be infrared photons. The decay of the dark gamma ray to a bunch of ordinary radio wave photons should be observed as radio noise. Note that Gariaev has observed transformation of laser light scattered from DNA to radio wave photons with frequencies down to 1 kHz at least.

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

The natural question is why h_{eff} us such that the resulting scale as photon wavelength corresponds to energy in scale 10-100 keV. The explanation could relate to the predicted exotic nuclei obtained by replacing some neutral color bonds connecting nucleons with charged ones and exchange of weak boson would affect this replacement. Could the weak physics associated with $h_{eff} \in [10^{12}, 10^{14}]$ be associated with dark color bonds? The reported annual variations of the nuclear reaction rates correlating with the distance of Earth from Sun suggest that these variations are induced by solar X rays [C10].

9 Dark Atomic Physics

Dark matter might be relevant also for atomic physics and in the sequel some speculations along these lines are represented. Previous considerations assumed that only field bodies can be dark and this is assumed also now. The notion of dark atom depends strongly on the precise meaning of the generalized imbedding space and I have considered several options.

1. The first option was based on the singular coverings $CD \times CP_2 \to CD/G_a \times CP_2/G_b$. This approach has a concrete connection to the quantization and the selection of quantization axes correlates closely with the identification of groups G_a and G_b. The questionable assumption is that elementary particle like partonic 2-surfaces remain invariant under the cyclic groups $G_a \times G_b$.

2. The next proposal was that both factor spaces and coverings of H are possible. For this option the notion of covering is somewhat unsatisfactory because it lacks concreteness. Singular factor of CD and CP_2 spaces make possible all rational values of Planck constant and one loses the vision about evolution as drift to the sectors of imbedding space characterized by increasing value of Planck constant.

3. The last proposal is based on the realization that basic quantum TGD could well explain the hierarchy of Planck constants in terms of singular covering spaces emerging naturally when the time derivatives of the imbedding space coordinates are many-valued functions of the canonical momentum densities. In this framework singular factors spaces are not possible and the formula $r \equiv \hbar/\hbar_0 = n_a n_b$ emerges naturally as well as charge fractionization. One also ends up to a unique recipe for how to obtain binding energies in this kind of situation and the results are consistent with the earlier formulas deduced on purely formal arguments. Groups G_a and G_b do not directly correspond to subgroups of isometry groups but the fractionization of quantum numbers implied by the scaling of Planck constant implies that wave functions for the selected quantization axes behave as if the maximal cyclic subgroups of G_a and G_b had a geometric meaning.

For covering space option fermion number is fractionized. The group algebra of $G_a \times G_b$ defines $n_a n_b$ single particle wave functions in the covering. The simplest option is that total fermion number is integer valued so that the many-sheeted structure is analogous to a full Fermi sphere

containing $n_a n_b$ fermions with fractional fermion number $1/n_a n_b$. A more general option allows states with fractional total fermion number varying from from $1/n_a n_b$ to 1. One could generalize the condition about integer fermion number so that it holds for the entire quantum state involving several covering regions and the condition would correspond to the $G_a \times G_b$ singletness of the physical states.

9.1 Dark Atoms And Dark Cyclotron States

The development of the notion of dark atom involves many side tracks which make me blush. The first naive guess was that dark atom would be obtained by simply replacing Planck constant with its scaled counterpart in the basic formulas and interpreting the results geometrically. After some obligatory twists and turns it became clear that this assumption is indeed the most plausible one. The main source of confusion has been the lack of precise view about what the hierarchy of Planck constants means at the level of imbedding space at space-time.

The rules are very simple when one takes the singular coverings assigned to the many-valuedness of the time-derivatives of imbedding space coordinates as functions of canonical momentum densities as a starting point.

1. The mass and charge of electron are fractionized as is also the reduced mass in Schrödinger equation. This implies the replacements $e \to e/r$, $m \to m/r$, and $\hbar \to r\hbar_0$, $r = n_a n_b$, in the general formula for the binding energy assigned with single sheet of the covering. If maximal number $n_a n_b$ are present corresponding to a full "Fermi sphere", the total binding energy is r times the binding energy associated with single sheet.

2. In the case of hydrogen atom the proportionality $E \propto m/\hbar^2$ implies that the binding energy for single sheet of the covering scales as $E \to E/(n_a n_b)^3$ and maximal binding energy scales as $E \to E/(n_a n_b)^2$. This conforms with the naive guess. For high values of the nuclear charge Z it can happen that the binding energy is larger than the rest mass and fractionization might take place when binding energy is above critical fraction of the rest mass.

3. In the case of cyclotron energies one must must decide what happens to the magnetic flux. Magnetic flux quantization states that the flux is proportional to $\hbar$ for each sheet separately. Hence one has $\Phi \to r\Phi$ for each sheet and the total flux scales as r^2. Since the dimensions of the flux quantum are scaled up by r the natural scaling of the size of flux quantum is by r^2. Therefore the quantization of the magnetic flux requires the scaling $B \to B/r$. The cyclotron energy for single sheet satisfies $E \propto \hbar qB/m$ and since both mass m and charge q become fractional, the energy E for single sheet remains invariant whereas total cyclotron energy is scaled up by r in accordance with the original guess and the assumption used in applications.

4. Dark cyclotron states are expected to be stable up to temperatures which are r times higher than for ordinary cyclotron states. The states of dark hydrogen atoms and its generalizations are expected to be stable at temperatures scaled down by $1/r^2$ in the first approximation.

5. Similar arguments allow to deduce the values of binding energies in the general case once the formula of the binding energy given by standard quantum theory is known.

The most general option option allows fractional atoms with proton and electron numbers varying from $1/r$ to 1. One can imagine also the possibility of fractional molecules. The analogs of chemical bonds between fractional hydrogen atoms with $N - k$ and k fractional electrons and protons can be considered and would give rise to a full shell of fractional electrons possessing an exceptional stability. These states would have proton and electron numbers equal to one.

Catalytic sites are one possible candidate for fractal electrons and catalyst activity might be perhaps understood as a strong tendency of fractal electron and its conjugate to fuse to form an ordinary electron.

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

The so called hydrino atom concept of Randell Mills [D20] represents one of the notions related to free energy research not taken seriously by the community of university physicists. What is claimed that hydrogen atom can exists as scaled down variants for which binding energies are much higher than usually due to the large Coulomb energy. The claim is that the quantum number n having integer values $n = 0, 1, 2, 3..$ and characterizing partially the energy levels of the hydrogen atom can have also inverse integer values $n = 1/2, 1/3, ...$ The claim of Mills is that the laboratory BlackLight Inc. led by him can produce a plasma state in which transitions to these exotic bound states can occur and liberate as a by-product usable energy.

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

The fractionized principal quantum number n claimed by Mills [D20] is reported to have at least the values $n = 1/k$, $k = 2, 3, 4, 5, 6, 7, 10$. First explanation would be in terms of Plack constant having also values smaller than $\hbar_0$ possible if singular factor spaces of causal diamond CD and CP_2 are allowed. q-Deformations of ordinary quantum mechanics are suggested strongly by the hierarchy of Jones inclusion associated with the hyper-finite factor of type II_1 about which WCW spinors are a basic example. This motivates the attempt to understand the claimed fractionization in terms of q-analog of hydrogen atom. The safest interpretation for them would be as states which can exist in ordinary imbedding space (and also in other branches)

The Laguerre polynomials appearing in the solution of Schrödinger equation for hydrogen atom possess quantum variant, so called q-Laguerre polynomials [A1], and one might hope that they would allow to realize this semiclassical picture at the level of solutions of appropriately modified Schrödinger equation and perhaps also resolve the difficulty associated with $n = 1/2$. Unfortunately, the polynomials discussed in [A1] correspond to $0 < q \leq 1$ rather than complex values of $q = exp(i\pi/m)$ on circle and the extrapolation of the formulas for energy eigenvalues gives complex energies.

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

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

$$\begin{aligned} \partial_x &\rightarrow \frac{1}{2}(\partial_x^{q)} + \partial_x^{\bar{q})}) \\ \partial_x^{q)} f &= \frac{f(qx) - f(x)}{(q-1)x} \quad , \\ q &= exp(i\pi/m) \end{aligned} \tag{9.1}$$

to guarantee hermiticity. When applied to the Laguerre equation

$$x\frac{d^2L_n}{dx^2} + (1-x)\frac{dL_n}{dx} = nL_n \quad , \tag{9.2}$$

and expanding L_n into Taylor series

$$L_n(x) = \sum_{n\geq 0} l_n x^n \quad , \tag{9.3}$$

one obtains difference equation

$$\begin{aligned} a_{n+1}l_{n+1} &+ b_n l_n = 0 \ , \\ a_{n+1} &= \frac{1}{4R_1^2}\left[R_{2n+1} - R_{2n} + 2R_{n+1}R_1 + 3R_1)\right] + \frac{1}{2R_1}\left[R_{n+1} + R_1\right] \\ b_n &= \frac{R_n}{2R_1} - n^{q)} + \frac{1}{2} \ , \\ R_n &= 2cos\left[(n-1)\pi/m\right] - 2cos\left[n\pi/m\right] \ . \end{aligned} \tag{9.4}$$

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

9.2.2 Polynomial solutions of q-Laquerre equation

The condition that the solution reduces to a polynomial reads as

$$b_n = 0 \tag{9.5}$$

and gives

$$n^{q)} = \frac{1}{2} + \frac{R_n}{2R_1} \ , \tag{9.6}$$

For $n = 1$ one has $n^{q)} = 1$ so that the ground state energy is not affected. At the limit $N \to \infty$ one obtains $n^{q)} \to n$ so that spectrum reduces to that for hydrogen atom. The periodicity $R_{n+2Nk} = R_n$ reflects the corresponding periodicity of the difference equation which suggests that only the values $n \leq 2m-1$ belong to the spectrum. Spectrum is actually symmetric with respect to the middle point $[N/2]$ which suggests that only $n < [m/2]$ corresponds to the physical spectrum. An analogous phenomenon occurs for representations of quantum groups [K3]. When m increases the spectrum approaches integer valued spectrum and one has $n > 1$ so that no fractionization in the desired sense occurs for polynomial solutions.

9.2.3 Non-polynomial solutions of q-Laquerre equation

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

$$\begin{aligned} L_n(x) &= P_a^{2m)}(x)\sum_k a^k x^{2mk} = P_a^{2m)}(x)\frac{1}{1-ax^{2m}} \ , \\ P_a^{2m)}(x) &= \sum_{k=0}^{2m-1} l_k x^k \ , \\ a &= \frac{l_{2m}}{l_0} \ , \end{aligned} \tag{9.7}$$

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

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

$$a = \prod_{k=1}^{2m} \frac{b_{2m-k}}{a_{2m-k+1}} \ . \tag{9.8}$$

This can be written more explicitly as

$$
\begin{aligned}
a &= (2R_1)^{2m} \prod_{k=1}^{2m} X_k \ , \\
X_k &= \frac{R_{2m-k} + (-2n^{q)} + 1)R_1}{R_{4m-2k+1} - R_{4m-2k} + 4R_{2m-k+1}R_1 + 2R_1^2 + 3R_1} \ , \\
R_n &= 2cos\left[(n-1)\pi/m\right] - 2cos\left[n\pi/m\right] \ . \qquad (9.9)
\end{aligned}
$$

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

9.2.4 Results of numerical calculations

Numerical calculations demonstrate following.

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

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

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

$$
P_a^{2m)}\left((\frac{1}{a})^{\frac{1}{2m}}\right) = 0 \ . \qquad (9.10)
$$

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

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

One can check directly whether x_∞ is near to zero for the experimentally suggested candidates for $n^{q)}$. **Table 3** summarizes the results of numerical calculations.

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

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

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

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

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

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

1. For the representations of quantum groups only the first m spins are realized [K3]. This suggests that there should exist a symmetry relating the coefficients l_n and l_{n+m} and implying $n^{q)} = 1/2$ for odd values of m. This symmetry would remove also the double degeneracy associated with the almost integer eigenvalues of $n^{q)}$. Also other fractional states are expected on basis of physical intuition.

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

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

There is indeed this kind of symmetry. From the formula

$$\begin{aligned} \frac{l_n}{l_0} &= (2R_1)^n \prod_{k=1}^{n} X_k \ , \\ X_k &= \frac{R_{n-k} + (-2n^{q)} + 1)R_1}{[R_{2n-2k+1} - R_{n-2k} + 4R_{n-k+1}R_1 + 2R_1^2 + 3R_1} \end{aligned} \tag{9.11}$$

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

$$\begin{aligned} A_{n+1} &= (-1)^m A_n \ , \\ A_n &= \prod_{k=1}^{m} \frac{b_{n+m-k}}{a_{n+m-k+1}} = \prod_{k=1}^{m} (2R_1)^m \prod_{k=1}^{m} X_{k+n} \ . \end{aligned} \tag{9.12}$$

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

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

$$\begin{aligned} P_a^{2m)} &= P_a^{m)}(1 - Ax^m) \ , \\ A &= A_0 \ . \end{aligned} \tag{9.13}$$

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

$$L_{1/2}(x) = \frac{P_a^{m)}(x)}{1 + Ax^m} \ . \tag{9.14}$$

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

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

$$\begin{aligned} \prod_{k=1}^{m}(R_k + \epsilon R_1) &= \prod_{k=1}^{m}(R_k - \epsilon R_1) \ , \\ \epsilon &= (2n^{q)} - 1 \ . \end{aligned} \tag{9.15}$$

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

This picture generalizes also to the case of even n so that also now solutions of the form of Eq. 9.14 are possible. In this case the condition is

$$\prod_{k=1}^{m}(R_k + \epsilon R_1) = -\prod_{k=1}^{m}(R_k - \epsilon R_1) \ . \tag{9.16}$$

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

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

$$n^{q)}(n) = \frac{1}{2} \pm \frac{R_n}{2R_1} \ , \ n = 1, ..., \frac{m}{2} \ , \tag{9.17}$$

and for odd values of m as

$$\begin{aligned} n_\pm^{q)}(n) &= \frac{1}{2} \pm \frac{R_n}{2R_1} \ , \ n = 1, ..., \frac{m+1}{2} - 1 \ , \\ n^{q)} &= 1/2 \ . \end{aligned} \tag{9.18}$$

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

$$n_\pm^{q)}(n) = \frac{1}{2} \pm \frac{(sin^2(\pi(n-1)/2m) - sin^2(\pi n/2m))}{2sin^2(\pi/2m)} \ . \tag{9.19}$$

At the limit of large m one has

$$n_+^{q)}(n) \simeq n \ , \ n_-^{q)}(n) \simeq 1-n \ . \tag{9.20}$$

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

9.2.6 Some comments

Some closing comments are in order.

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

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

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

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

9.3 Shy Positrons

The latest weird looking effect in atomic physics is the observation that positrium atoms consisting of positron and electron scatter particles almost as if they were lonely electrons [C16, C9]. The effect has been christened cloaking effect for positron.

The following arguments represent the first attempts to understand the cloaking of positron in terms of these notions.

1. Let us start with the erratic argument since it comes first in mind. If positron and electron correspond to different space-time sheets and if the scattered particles are at the space-time sheet of electron then they do not see positron's Coulombic field at all. The objection is obvious. If positron interacts with the electron with its full electromagnetic charge to form a bound state, the corresponding electric flux at electron's space-time sheet is expected to combine with the electric flux of electron so that positronium would look like neutral particle after all. Does the electric flux of positron return back to the space-time sheet of positronium at some distance larger than the radius of atom? Why should it do this? No obvious answer.

2. Assume that positron dark but still interacts classically with electron via Coulomb potential. In TGD Universe darkness means that positron has large $\hbar$ and Compton size much larger than positronic wormhole throat (actually wormhole contact but this is a minor complication) would have more or less constant wave function in the volume of this larger space-time sheet characterized by zoomed up Compton length of electron. The scattering particle would see point-like electron plus background charge diffused in a much larger volume. If the value of $\hbar$ is large enough, the effect of this constant charge density to the scattering is small and only electron would be seen.

3. As a matter fact, I have proposed this kind of mechanism to explain how the Coulomb wall, which is the basic argument against cold fusion could be overcome by the incoming deuteron nucleus [L2], [L2]. Some fraction of deuteron nuclei in the palladium target would be dark and have large size just as positron in the above example. It is also possible that only the protons of these nuclei are dark. I have also proposed that dark protons explain the effective chemical formula $H_{1.5}O$ of water in scattering by neutrons and electrons in atto-second time scale [L2], [L2]. The connection with cloaked positrons is highly suggestive.

4. Also one of TGD inspired proposals for the absence of antimatter is that antiparticles reside at different space-time sheets as dark matter and are apparently absent [K31]. Cloaking positrons (shy as also their discoverer Dirac!) might provide an experimental supports for these ideas.

The recent view about the detailed structure of elementary particles forces to consider the above proposal in more detail.

1. According to this view all particles are weak string like objects having wormhole contacts at its ends and magnetically charged wormhole throats (four altogether) at the ends of the string like objects with length given by the weak length cale connected by a magnetic flux tube at both space-time sheets. Topological condensation means that these structures in turn are glued to larger space-time sheets and this generates one or more wormhole contacts for which also particle interpretation is highly suggestive and could serve as space-time correlate for interactions described in terms of particle exchanges. As far electrodynamics is considered, the second ends of weak strings containing neutrino pairs are effectively non-existing. In the case of fermions also only the second wormhole throat carrying the fermion number is effectively present so that for practical purposes weak string is only responsible for the massivation of the fermions. In the case of photons both wormhole throats carry fermion number.

2. An interesting question is whether the formation of bound states of two charged particles at the same space-time sheet could involve magnetic flux tubes connecting magnetically charged wormhole throats associated with the two particles. If so, Kähler magnetic monopoles would be part of even atomic and molecular physics. I have proposed already earlier that gravitational interaction in astrophysical scales involves magnetic flux tubes. These flux tubes would have o interpretation as analogs of say photons responsible for bound state energy. In principle it is indeed possible that the energies of the two wormhole throats are of opposite sign for topological sum contact so that the net energy of the wormhole contact pair responsible for the interaction could be negative.

3. Also the interaction of positron and electron would be based on topological condensation at the same space-time sheet and the formation of wormhole contacts mediating the interaction. Also now bound states could be glued together by magnetically charged wormhole contacts. In the case of dark positron, the details of the interaction are rather intricate since dark positron would correspond to a multi-sheeted structure analogous to Riemann surface with different sheets identified in terms of the roots of the equation relating generalized velocities defined by the time derivatives of the imbedding space coordinates to corresponding canonical momentum densities.

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