Criticality and dark matter

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Contents

Abstract

Quantum criticality is one of the corner stone assumptions of TGD. The value of Kähler coupling strength fixes quantum TGD and is analogous to critical temperature. TGD Universe would be quantum critical. What does this mean is however far from obvious and I have pondered the notion repeatedly both from the point of view of mathematical description and phenomenology. Dark matter as a hierarchy of phases of ordinary matter labelled by the value of effective Planck constant h_{eff} following as prediction of adelic physics suggests a general approach to quantum criticality. The chapter begins with general ideas about quantum criticality and phase transitions. Also applications to condensed matter physics and biology are considered besides applications, which might be labelled as miscellaneous.

1 Introduction

Quantum criticality is one of the corner stone assumptions of TGD. The value of Kähler coupling strength fixes quantum TGD and is analogous to critical temperature. TGD Universe would be quantum critical. What does this mean is however far from obvious and I have pondered the notion repeatedly both from the point of view of mathematical description and phenomenology [K24, K54].

1. Criticality is characterized by long range correlations and sensitivity to external perturbations and living systems define an excellent example of critical systems - even in the scale of populations since without sensitivity and long range correlations cultural evolution and society would not be possible. For a physicist with the conceptual tools of existing theoretical physics the recent information society in which the actions of people at different side of globe are highly correlated, should look like a miracle.

2. The hierarchy of Planck constants with dark matter identified as phases of ordinary matter with non-standard value $h_{eff} = n \times h$ of Planck constant is one of the "almost-predictions" of TGD is definitely something essentially new physics. The phase transition transforming ordinary matter to dark matter in this sense generates long range quantal correlations and even macroscopic quantum coherence.

   Finding of a universal mechanism generating dark matter have been a key challenge during last ten years. Could it be that criticality is always accompanied by the generation of dark matter? If this is the case, the recipe would be stupifuingly simple: create a critical system! Dark matter would be everywhere and we would have observed its effects for centuries! Magnetic flux tubes (possibly carrying monopole flux) define the space-time correlates for long range correlations at criticality and would carry the dark matter. They are indeed key players in TGD inspired quantum biology.

3. Change of symmetry is assigned with criticality as also conformal symmetry (in 2-D case). In TGD framework conformal symmetry is extended and infinite hierarchy of breakings of conformal symmetry so that a sub-algebras of various conformal algebras with conformal weights coming as integer multiples of integer n defining h_{eff} would occur.

4. Phase separation is what typically occurs at criticality and one should understand also this. The strengthening of this hypothesis with the assumption $h_{eff} = h_{gr}$, where $h_{gr} = GMm/v_0$ is is the gravitational Planck constant originally introduced by Nottale. In the formula v_0 has dimensions of velocity, and will be proposed to be determined by a condition relating the size of the system with mass M to the radius within which the wave function of particle m with $h_{eff} = h_{gr}$ is localized in the gravitational field of M.

5. The condition $h_{eff} = h_{gr}$ implies that the integer n in h_{eff} is proportional to the mass of particle. The implication is that particles with different masses reside at flux tubes with different Planck constant and separation of phases indeed occurs.

6. What is remarkable is that neither gravitational Compton length nor cyclotron energy spectrum depends on the mass of the particle. This universality could play key role in living matter. One can assign Planck constant also to other interactions such as electromagnetic interaction so that one would have $h_{em} = Z_1 Z_2 e^2/v_0$. The phase transition could take place

when the perturbation series based on the coupling strength $\alpha = Z_1 Z_2 e^2/\hbar$ ceases to converge. In the new phase perturbation series would converge since the coupling strength is proportional to $1/h_{eff}$. Hence criticality and separation into phases serve as criteria as one tries to see whether the earlier proposals for the mechanisms giving rise to large h_{eff} phases make sense. One can also check whether the systems to which large h_{eff} has been assigned are indeed critical.

The motivation for this work came from super-fluidity. Superfluids exhibit rather mysterious looking effects such as fountain effect and what looks like quantum coherence of superfluid containers, which should be classically isolated. These findings serve as a motivation for the proposal that genuine superfluid portion of superfluid corresponds to a large h_{eff} phase near criticality at least and that also in other phase transition like phenomena a phase transition to dark phase occurs near the vicinity.

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` [L1].

2 Criticality In TGD Framework

In the following the proposal that quantum criticality or even criticality (with thermodynamical criticality included) could in TGD framework correspond to phase transition generating dark matter identified as phases of the ordinary matter with non-standard value $h_{eff} = n \times h$ of Planck constant and residing at dark magnetic flux tubes is discussed.

The precise meaning of quantum criticality has remained frustratingly fuzzy since the long range fluctuations and possible quanta associated with them do not correspond to any of the co-existing phases naturally but rather to transitions between them. Here Zero Energy Ontology (ZEO) in which basic objects are time evolutions suggests an elegant description: the ends of space-time surfaces at opposite boundaries of CD correspond to different values of h_{eff}. This would also give a connection with inclusions of hyper-finite factors: the integer m characterizing the inclusion equals to the radion $m = h_{eff}(f)/h_{eff}(i)$ of Planck constants for final and initial phases.

2.1 Mathematical Approach To Criticality

Concerning the understanding of criticality one can proceed purely mathematically. Consider first 2-dimensional systems and 4-D conformal invariance of Yang-Mills theories.

1. In 2-dimensional case the behavior of the system at criticality is universal and the dependence of various parameters on temperature and possible other critical parameters can be expressed in terms of critical exponents predicted in the case of effectively 2-dimensional systems by conformal field theory discovered by Russian theoreticians Zamolodchikov, Polyakov and Belavin [B2]. To my opinion, besides twistor approach this is one of the few really significant steps in theoretical physics during last forty years.

2. Twistors discovered by Penrose relate closely to 4-D conformal invariance generalized to Yangian symmetry [A1] [B7, B5, B6] in the approach developed by Nima Arkani-Hamed and collaborators recently. 2-dimensional conformal field theories are relatively well-understood and classified. String models apply the notions and formalism of conformal field theories.

3. The notion of conformal symmetry breaking emerges from basic mathematics and is much deeper than its variant based on Higgs mechanism able to only reproduce the mass spectrum but not to predict it: in p-adic thermodynamics based on super-conformal invariance prediction becomes possible [K33].

2.1.1 Basic Building Bricks Of TGD Vision

The big vision is that 2-D conformal invariance generalizes to 4-D context [K15, K24] and the conjecture is that it can be extended to Yangian symmetry assignable - not to finite-D conformal algebra of Minkowski space - but to the infinite-D generalization of 2-D conformal algebra to 4-D

context. The details of this generalization are not understood but the building bricks have been identified.

1. One building brick is the infinite-D group of symplectic symmetries of $\delta M^4_{-+} \times CP_2$ having the structure of conformal algebra but the radial light-like coordinate r_M of δM^4_+ replacing complex coordinate z: r_M presumably allows a continuation to a hyper-complex analog of complex coordinate. One can say that finite-D Lie algebra defining Kac-Moody algebrais replaced with an infinite-D symplectic algebra of $S^2 \times CP_2$ and made local with respect to r_M

2. Second building brick is defined by the conformal symmetries of S^2 depending parametrically on r_M and are due to metric 2-dimensionality of δM^4_+. These symmetries are possible only in 4-D Minkowski space. The isometry algebra of δM^4_+ is isomorphic with that of ordinary conformal transformations (local radial scaling compensates the local conformal scaling).

3. Light-like orbits of the partonic 2-surfaces have also the analog of the extended conformal transformations as conformal symmetries and respect light-likeness.

4. At least in space-time regions with Minkowskian signature of the induced metric spinor modes are localized to string 2-D world sheets from the condition that electric charge is well-defined for the modes. This guarantees that weak gauge potentials are pure gauge at string world sheets and eliminates coupling of fermions to classical weak fields which would be a strong arguments against the notion of induced gauge field. Whether string world sheets and partonic 2-surfaces are actually dual as far as quantum TGD is considered, is still an open question.

The great challenge is to combine these building bricks to single coherent mathematical whole. Yangian algebra, which is multi-local with locus generalized from a point to partonic 2-surface would be the outcome. Twistors would be part of this vision: M^4 and CP_2 are indeed the unique 4-D manifolds allowing twistor space with Kähler structure [A3]. Number theoretic vision involving classical number fields would be part of this vision. 4-dimensionality of space-time surfaces would follow from associativity condition stating that space-time surfaces have associative tangent - or normal space as surfaces in 8-D embedding space endowed with octonionic tangent space structure. 2-dimensionality of the basic dynamical objects would follow from the condition that fundamental objects have commutative tangent - or normal space. String world sheets/partonic 2-surfaces would be commutative/co-commutative or vice versa.

2.1.2 Hierarchy Of Criticalities And Hierarchy Breakings Of Conformal Invariance

The TGD picture about quantum criticality connects it to the failure of classical non-determinism for Kähler action defining the space-time dynamics. A connection with the hierarchy of Planck constants [K19] and therefore dark matter in TGD sense emerges: the number n of conformal equivalence classes for space-time surfaces with fixed ends at the boundaries of causal diamond corresponds to the integer n appearing in the definition of Planck constant $h_{eff} = n \times h$.

A more detailed description for the breaking of conformal invariance is as follows. The statement that sub-algebra V_n of full conformal algebra annihilates physical states means that the generators L_{kn}, $k > 0$, $n > 0$ fixed, annihilate physical states. The generators L_{-kn}, $k > 0$, create zero norm states. Virasoro generators can be of course replaced with generators of Kac-Moody algebra and even those of the symplectic algebra defined above.

Since the action of generators L_m on the algebra spanned by generators $Ln + m$, $m > 0$, does not lead out from this algebra (ideal is in question), one can pose a stronger condition that all generators with conformal weight $k \geq n$ annihilate the physical states and the space of physical states would be generated by generators L_k, $0 < k < n$. Similar picture would hold for also for Kac-Moody algebras and symplectic algebra of $\delta M^4_+ \times CP_2$ with light-like radial coordinate of δM^4_+ taking the role of z. Since conformal charge comes as n-multiples of $\hbar$, one could say that one has $h_{eff} = n \times h$.

The breaking of conformal invariance would transform finite number of gauge degrees to discrete physical degrees of freedom at criticality. The long range fluctuations associated with criticality are potentially present as gauge degrees of freedom, and at criticality the breaking of conformal

invariance takes place and these gauge degrees of freedom are transformed to genuine degrees of freedom inducing the long range correlations at criticality.

Changes of symmetry are assigned with criticality since Landau. Could one say that the conformal subalgebra defining the genuine conformal symmetries changes at criticality and this makes the gauge degrees of freedom visible at criticality?

2.1.3 Emergence Of The Covering Spaces Associated With The Hierarchy Of Planck Constants

The original vision was that the hierarchy of Planck constants corresponds to a hierarchy of n-fold singular coverings of the embedding space - or more precisely given causal diamond (CD) forming a book-like structure with pages labelled by the effective value of Planck constant $h_{eff}/h = n$. This view allowed to understand the basic aspects of the hierarchy: in particular, the relative darkness of phases associated with different values of n. The generalization of embedding space is however un-necessary. The non-determinism of Kähler action allows to replace singular coverings of embedding space with the identification of space-time surfaces with their singular coverings. Space-like 3-surfaces at the opposite boundaries of CD are connected by a multi-sheeted covering with sheets co-inciding at the ends.

How does this picture relate to the breaking of conformal symmetry? The idea is simple. One goes to n-fold covering space by replacing z coordinate by $w = z^{1/n}$. With respect to the new variable w one has just the ordinary conformal algebra with integer conformal weights but in n-fold singular covering of complex plane or sphere. Singularity of the generators explains why $L_k(w)$, $k < n$, do not annihilate physical states anymore. Sub-algebra would consist of non-singular generators and would act as symmetries and also the stronger condition that Lk, $k \geq n$, annihilates the physical states could be satisfied. Classically this would mean that the corresponding classical Noether charges for Kähler action are non-vanishing.

Another manner to look the same situation is to use z coordinate. Now conformal weight is fractionized as integer multiples of $1/n$ and since the generators with fractional conformal weight are singular at origin, one cannot assume that they annihilate the physical states: fractional conformal invariance is broken. Quantally the above conditions on physical states would be satisfied. Sphere - perhaps the sphere assigned with the light-cone boundary or geodesic sphere of CP_2 - would be effectively replaced with its n-fold covering space, and due to conformal invariance one would have n additional discrete degrees of freedom.

These discrete degrees of freedom would define n-dimensional Hilbert space space by the n fractional conformal generators. One can also second quantize by assigning oscillator operators to these discrete degrees of freedom. In this picture the effective quantization of Planck constant would result from the condition that conformal weights for the physical states are integers.

2.1.4 Other Connections

The values of effective Planck constants seems to have profound connections to several key ideas of TGD.

1. As already found, the connection with the hierarchy of broken conformal symmetries is highly suggestive. The integer $h_{eff}/h = n$ would characterize the sub-algebra of gauge conformal symmetries.

2. There seems to be a connection with negentropic entanglement [K29] associated with the density matrix of the state resulting in state function reduction, which is proportional to unit matrix - projector to an eigen space of density matrix. Negentropic entanglement would occur in the new discrete degrees of freedom most naturally. In the special 2-particle case negentropic entanglement corresponds to unitary entanglement encountered in quantum computation: large h_{eff} makes possible long-lived entanglement and its negentropic character implies that Negentropy Maximization Principle [K29] favors its generation. An interesting hypothesis to be killed is that the p-adic prime characterizing the space-time sheet string world sheet or partonic 2-surface divides n.

3. The realization of number theoretic univarsality in terms of strong form holography assumes that string world sheets and partonic 2-surfaces serve as "space-time genes" allowing continuation to preferred extremals. These 2-surfaces are characterized by parameters, which belong to an extension of rationals inducing extensions of p-adic number fields. One has a hierarchy of extensions of increasing complexity. Given extension is characterized by preferred primes known as ramified primes with the property that their decomposition to a products of of primes of extension contains higher powers than one. The product n of ramified rational primes characterizes the extension and is an integer.

   p-Adic continuations identifiable as imaginations would be due to the existence of p-adic pseudo-constants. The continuation could fail for most configurations of partonic 2-surfaces and string world sheets in the real sector: the interpretation would be that some space-time surfaces can be imagined but not realized [K35]. For certain extensions the number of realizable imaginations could be exceptionally large. These extensions would be winners in the number theoretic fight for survivalandcorresponding ramified primes would be preferred p-adic primes. NMP implies a generalization of p-adic length scale hypothesis stating that primes near but below powers of prime are physically favored and thus selected in number theoretic evolution.

   $h_{eff}/h = n$ gives the number of sheets of covering and a more plausible identification is as the dimension of covering assignable to number theoretic discretization of space-time surface [L17]. This dimension is the dimension of Galois group for the extension of rationals or its factor is highly suggestive and would lead to a direct connection with the number theoretic view about evolution.

2.1.5 Hierarchy of Planck constants, space-time surfaces as covering spaces, and adelic physics

From the beginning it was clear that $h_{eff}/h = n$ corresponds to the number of sheets for a covering space of some kind. First the covering was assigned with the causal diamonds. Later I assigned it with space-time surfaces but the details of the covering remained unclear. The final identification emerged only in the beginning of 2017.

Number theoretical universality (NTU) leads to the notion of adelic space-time surface (monadic manifold) involving a discretization in an extension of rationals defining particular level in the hierarchy of adeles defining evolutionary hierarchy. The first formulation was proposed in [K55] and more elegant formulation in [L17].

The key constraint is NTU for adelic space-time containing sheets in the real sector and various padic sectors, which are extensions of p-adic number fields induced by an extension of rationals which can contain also powers of a root of e inducing finite-D extension of p-adic numbers (e^p is ordinary p-adic number in Q_p).

One identifies the numbers in the extension of rationals as common for all number fields and demands that embedding space has a discretization in an extension of rationals in the sense that the preferred coordinates of embedding space implied by isometries belong to extension of rationals for the points of number theoretic discretization. This implies that the versions of isometries with group parameters in the extension of rationals act as discrete versions of symmetries. The correspondence between real and p-adic variants of the embedding space is extremely discontinuous for given adelic embedding space (there is hierarchy of them with levels characterized by extensions of rationals). Space-time surfaces typically contain rather small set of points in the extension ($x^n + yn^2 = z^n$ contains no rationals for $n > 2$!). Hence one expects a discretization with a finite cutoff length at space-time level for sufficiently low space-time dimension $D = 4$ could be enough.

After that one assigns in the real sector an open set to each point of discretization and these open sets define a manifold covering. In p-adic sector one can assign 8:th Cartesian power of ordinary p-adic numbers to each point of number theoretic discretization. This gives both discretization and smooth local manifold structure. What is important is that Galois group of the extension acts on these discretizations and one obtains from a given discretization a covering space with the number of sheets equal to a factor of the order of Galois group.

$h_{eff}/h = n$ was identified from the beginning as the dimension of poly-sheeted covering assignable to space-time surface. The number n of sheets would naturally a factor of the or-

der of Galois group implying $h_{eff}/h = n$ bound to increase during number theoretic evolution so that the algebraic complexity increases. Note that WCW decomposes into sectors corresponding to the extensions of rationals and the dimension of the extension is bound to increase in the long run by localizations to various sectors in self measurements [K29]. Dark matter hierarchy represents number theoretical/adelic physics and therefore has now rather rigorous mathematical justification. It is however good to recall that $h_{eff}/h = n$ hypothesis emerged from an experimental anomaly: radiation at ELF frequencies had quantal effects of vertebrate brain impossible in standard quantum theory since the energies $E = hf$ of photons are ridiculously small as compared to thermal energy.

Indeed, since n is positive integer evolution is analogous to a diffusion in half-line and n unavoidably increases in the long run just as the particle diffuses farther away from origin (by looking what gradually happens near paper basket one understands what this means). The increase of n implies the increase of maximal negentropy and thus of negentropy. Negentropy Maximization Principle (NMP) follows from adelic physics alone and there is no need to postulate it separately. Things get better in the long run although we do not live in the best possible world as Leibniz who first proposed the notion of monad proposed!

2.2 Phenomenological Approach To Criticality

These statements do not have any obvious content for an experimentalist. One should have also a more concrete view about criticality. Theoretician would call this phenomenology.

1. Phase transitions and criticality are essential piece of being alive. Criticality means high sensitivity to signals and makes sensory perception possible. Criticality implies also long range correlations making us coherent units. The long range correlations between people who have never seen each other, like most of us, make possibly society, and demonstrate that the criticality appears also at collective levels of life and consciousness: usually biologists dismiss this. For physicist - at least me - the correlation between behaviors of him and his cat looks like a miracle!

2. Self-organization takes place by phase transitions and criticality with long range correlations. In zero energy ontology (ZEO) self-organisation is however self-organisation for entire temporal patterns of space-time dynamics characterised by the 3-surfaces at the ends of causal diamond so that behaviours rather than states emerge. Also the synergy is made possible by criticality.

3. Criticality appears only in a very narrow range of control parameters and is therefore difficult to produce critical systems tend to fall off from criticality: good example is our society which is all the time at the verge of some kind of catastrophe.

One can build refined and highly predictive conformal field theory models but they do not tell what are the microscopic mechanisms behind criticality.

1. What are the space-time correlates for criticality and long range correlations? Something must quite concretely connect the sub-systems, bind them to single coherent unit at criticality. Magnetic flux tubes is of course the TGD based answer! But this is not enough. The long range correlations must be quantal and this requires that Planck constant is large: $h_{eff} = n/times; h$! Dark matter! The emergence of dark matter phase makes system critical! TGD Universe is critical at fundamental level and this implies that this dark matter is present at all length scales.

2. Long range interactions certainly define a basic characteristic of criticality. How do they emerge? Does some universal mechanism exist? $h_{eff} = n \times h$ hypothesis and p-adic length cale hypothesis allow to understand this. Weak bosons are effectively massless below weak boson Compton length - about 10^{-17} meters. When h_{eff} is scaled up by n, this Compton length is scaled up by n too. Weak interactions would become long ranged below much longer length scale, say even cellular scale and among other things explain chiral selection of biomolecules. Similar argument can be carried out for gluons and dark/p-adically scaled down) quarks and gluons would also appear in living matter.

3. Phase separation is key feature of criticality. How does this separation take place? Is there a universal mechanism as suggested by the fact that at criticality everything is universal. The answer relies on the notion of many-sheeted space-time, $h_{eff} = n \times h$ hierarchy, and the notion of gravitational Planck constant $\hbar_{gr} = GMm/v_0$ introduced originally by Nottale [**?**]. The additional hypothesis [K45]

$$h_{eff} = h_{gr}$$

brings in gravitational interaction: the gravitational Planck constant is assigned with gravitation mediated by magnetic flux tubes connecting the two dark systems. The hypothesis predicts that h_{eff} is proportional to particle mass. This means each particle type is at its own dark flux tube/quantum nicely separated from each other. This would explain the phase separation at criticality even if the phase transformed after criticality to ordinary $h_{eff} = h$ phase. Pollack's exclusion zones (EZs) [L4] show the effect too: charge separation occurs and impurities in EZ get put of it. $h_{eff} = h_{gr}$ hypothesis implies that the scaled up Compton length becomes $\lambda_{gr} = GM/v_0$ and does not depend on particle mass at all: and ideal outcome concerning collective quantum coherence. In living matter with dynamics characterized by phase transitions this phase separation of different biologically important molecules would be in crucial role. The cell would not be anymore a random soup of huge number of different biomolecules but nicely arranged archive.

Critical reader - and even me after 9 ears of work! - can of course ask what the mass M appearing in the formula for h_{gr} really is. The logical answer is that it is the portion of matter that is dark: to this dark particles couple. In the Nottale's original model M and in TGD generalization of this model M corresponds to the entire mass of say Sun. This makes sense only if the approximate Bohr orbits in solar system reflect the situation when most of the matter in solar system was dark. Nowadays this is not the case anymore. For Earth the portion of dark matter in TGD sense should be something like 4×10^{-4} as becomes clear by just looking the values of the energies associated with dark cyclotron photons and requiring that they are in the range of bio-photon energies (dark photons would transforming to ordinary photons produce bio-photons). Without this assumption the range of bio-photon energies would be above 40 keV.

Besides dark matter also p-adically scaled up variants of weak interaction physics are possible: now weak bosons would be light but not massless above the Compton length which would be scaled up. In the TGD based model of living matter both dark matter and p-adically scaled up variants of particles appear and both are crucial for understanding metabolism. Both kind of phases could appear universally in critical systems. Dark matter would be a critical phenomenon and appear also in thermodynamical phase transitions, not only in quantum phase transitions.

Also so called free energy phenomena, cold fusion, remote mental interactions, etc are critical phenomena and therefore very difficult to replicate unless one knows this so that it is very easy to label researchers of these phenomena crackpots. The researchers in these fields could be seen as victims of the phenomenon they are studying! Life of course is also a critical phenomenon but even the vulgar skeptics are living and conscious beings and usually do not try to deny this!

2.3 Do The Magnetic Flux Quanta Associated With Criticality Carry Monopole Flux?

TGD allows the possibility that the magnetic flux quanta associated with criticality carry monopole flux. In Maxwellian electrodynamics this is not possible. These flux tubes are associated with elementary particles: in this case they have open string like portions at parallel space-time sheets connected at their ends by wormhole contacts to form a closed two-sheeted loop. Since the magnetic monopole flux is conserved along the flux tube, one has full reason to wonder whether these closed magnetic flux tubes can be created from vacuum.

One can imagine two ways to create flux loops: in a continuous energy conserving manner classically or by quantum jump in which quantum sub-Universe associated with given causal diamond (CD) is re-created (recall that causal diamonds define the observable Universes and they have finite size as intersections of future and past directed light-ones)

Consider for simplicity flux tubes which are circular. How the flux tubes can be generated?

1. One possibility is that an existing circular flux tube splits into two. This would take place by self-reconnection: circular flux tubes evolves first a figure eight shape, and after that self-reconnects and splits to two circular flux tubes. Figure eight shape is necessary because the direction of the conserved magnetic flux defines orientation and flux tube portions with opposite orientations cannot join. This mechanism allows replication of flux tubes and could be behind the $1 \to 2$ decays of elementary particles and the reverse reactions. It could be also behind biological replication at both DNA and cell level, and even higher levels. The reconnection of U-shaped flux tubes for two systems so that they become connected by a pair of flux tubes is the reverse of this process and is proposed to define fundamental mechanism of directed attention.

2. Can one imagine a purely classical mechanism in which flux tubes would be generated from nothing? An idealization as a closed string allows to imagine a closed string which begins from point and expands: in string models this kind of closed strings indeed pop up from vacuum. Energy conservation however forbids the classical occurrence of this process. Therefore this process is possible only in path integral formalism which allows processes, which are classically impossible.

   In TGD framework space-time surfaces appearing in the functional integral are extremals of Kähler action and conserve energy so that this kind of process is impossible. It is difficult to say what happens when the string is replaced with a flux tube having a a finite thickness: could this make it possible an energy conserving process in which initial state would not contain flux tubes but final would contain flux tubes? At elementary particle level this would mean generation of a particle or a pair from vacuum but this does not take place. Note that the development of Higgs expectation can be interpreted as generation of new vacuum state which contains Higgs bosons: TGD counterpart of the ground state would be a superposition of states containing various numbers of flux loops.

3. One can however consider a *quantum jump* generating flux tube from nothing. The sequence of quantum jumps consist of sub-sequences consisting of state function reductions to a fixed boundary of CD ("upper" or "lower"). A sub-sequence defining self corresponds to a sequence of repeated quantum measurements having no effect on the state in ordinary quantum measurement theory. In TGD state function reduction has effect on the second boundary. Or to be precise, on the wave function in the moduli space associated with the second boundary with moduli characterising among other things the temporal distance from the fixed boundary. This effect gives rise to the experienced flow of time as increase of the average temporal distance between the tips of CD and also to its arrow.

   These state function sequences do not last for ever (self has finite lifetime!): Negentropy Maximization Principle (NMP) eventually forces state function reduction at the opposite boundary of CD. The new state can contain flux loops which did not exist in the initial state. These flux loops could exists also outside the CD but this is not relevant for the physics experienced by the conscious observer associated with given CD.

   The generation of this kind of monopole flux loops from nothing could be seen as a direct proof for macroscopic quantum jumps re-creating the Universe. Penrose proposed something similar in Shadows of Mind: quasicrystals are non-periodic lattices which look like lattices but - unlike ordinary crystals - cannot be generated by gradual lattice growth but must pop up in quantal manner to existence.

3 What's New In TGD Inspired View About Phase Transitions?

The comment of Ulla mentioned Kosterlitz-Thouless phases transition and its infinite order. I am not a condensed matter physicist so that my knowledge and understanding are rather rudimentary and I had to go to Wikipedia (see `http://tinyurl.com/ybevezgf`). I realized that I have not payed attention to the classification of types of phase transitions, while speaking of quantum criticality [**?**]. Also the relationship of ZEO inspired description of phase transitions to that of

standard positive energy ontology has remained poorly understood. In the following I try to represent various TGD inspired visions about phase transitions and criticality in organized manner and relate them to the standard description.

3.1 About Thermal And Quantum Phase Transitions

It is good to beging with something concrete. Wikipedia article lists examples about different types of phase transitions. These phase transitions are thermodynamical.

1. In first order phase thermodynamical phase transitions heat is absorbed and phases appear as mixed. Melting of ice and boiling of water represent the basic examples. Breaking of continuous translation symmetry occurs in crystallization and symmetry is smaller at low temperature. One speaks of spontaneous symmetry breaking: thermodynamical fluctuations are not able to destroy the configuration breaking the symmetry.

2. Second order phase transitions are also called continuous and they also break continuous symmetries. Susceptility diverges, correlation range is infinite, and power-law behaviour applies to correlations. Ferromagnetic, super-conducting, and superfluid transitions are examples. Conformal field theory predics power-law behavior and infinite correlation length. Infinite susceptility means that system is very sensitive to external perturbations. First order phase transition becomes second order transition at critical point. Here the reduction by strong form of holography might make sense for high Tc superconductors at least (they are effectively 2-D).

3. Infinite order phase transitions are also possible. Kosterlitz-Thouless phase transition occurring in 2-D systems allowing conformal symmetries represents this kind of transition. These phase transitions are continuous but do not break continuous symmetries as usually.

4. There are also liquid-glass phase transitions. Their existence is hypothetical. The final state depends on the history of transition. Glass state itself is more like an on going phase transition rather than phase.

These phase transitions are thermal and driven by thermal fluctuations. Also quantum phase transitions (see `http://tinyurl.com/yblptwr6`) are possible.

1. According to the standard definition they are possible only at zero temperature and driven by quantum fluctuations. For instance, gauge coupling strength would be analogous to quantum temperature. This is a natural definition in standard ontology, in which thermodynamics and quantum theory are descriptions at different levels.

   Quantum TGD can be seen as a square root of thermodynamics in a well-defined sense and it makes possible to speak about quantum phase transitions also at finite temperature if one can identify the temperature like parameter characterizing single particle states as a kind of holographic representations of the ordinary temperature.

2. The traces of quantum phase transitions are argued to be visible also at finite temperatures if the energy gap is larger than the thermal energy: $\hbar\omega > \geq T$. In TGD framework Planck constant has a spectrum $h_{eff}/h = n$ and allows very large values. This allows quantum phase transitions even at room temperature and TGD inspired quantum biology relies crucially on this. What is of special interest that also ordinary thermal phase transitions might be accompanied by quantum phase transitions occurring at the level of magnetic body and perhaps even inducing the ordinary thermal phase transition.

3. Quantum critical phase transitions occur at critical point and are second order phase transitions so that susceptibility diverges and system is highly sensitive to perturbations and so in wide range around critical temperature (zero in standard theory). Long range fluctuations are generated and this conforms with the TGD vision about the role of large h_{eff} phases and generalized conformal symmetry: which also implies that the region around criticality is wide (exponentially decaying correlations replaced with power law correlations).

3.2 Some Examples Of Quantum Phase Transitions In TGD Framework

TGD suggests some examples of quantum phase transition like phenomena.

1. Bose-Einstein (BE) condensate consisting of bosons in same state would represent a typical quantum phase. I have been talking a lot about cyclotron BE condensates at dark magnetic flux tubes [K26, K40, K41]. The bosonic particles would be in the same cyclotron state. One can consider also the analogs of Cooper pairs with members at flux tubes of a pair of parallel flux tubes with magnetic fields in same or opposite direction. One member at each tube having spin 1 or zero. This would give rise to high T_c superconductivity.

2. One natural mechanism of quantum phase transition would be condensation to a new single particle state. The rate for an additions of new particle to condensate is proportional to $N + 1$ and disappearance of particle from it to N, where N is the number of particles in condensate. The net rate for BE condensation is difference of these and non-vanishing.

   Quantum fluctuations induce phase transition between states of this condensate at criticality. For instance, cyclotron condensate could make a spontaneous phase transition to a lower energy state by a change of cyclotron energy state and energy would be emitted as a dark cyclotron radiation. This kind of dark photon radiation could in turn induce cyclotron transition to a higher cyclotron state at some other flux tube. If NMP holds true it could pose restrictions for the occurrence of transitions since one expects that negentropy is reduced. The transitions should involve negentropy transfer from the system.

   The irradiation of cyclotron BE condensate with some cyclotron frequency could explain cyclotron phase transition increasing the energy of the cyclotron state. This kind of transition could explain the effecs of ELF em fields on vertebrate brain [J2] in terms of cyclotron phase transition and perhaps serving as a universal communication and control mechanism in the communications of the magnetic body with biological body and other magnetic bodies [K17]. The perturbation of microtubules by an oscillating voltage [J1] (see `http://tinyurl.com/ze366ny`) has been reported by the group of Bandyonophyay [J3] to induce what I have interpreted as quantum phase transition [L10] (see `http://tinyurl.com/yatfreqe`).

   External energy feed is essential and dark cyclotron radiation or generalized Josephson radiation from cell membrane acting as generalized Josephson junction and propagating along flux tubes could provide it. Cyclotron energy is scaled up by h_{eff}/h and would be of the order of biophoton energy in TGD inspired model of living matter and considerably above thermal energy at physiological temperature.

3. Also quantum phase transitions affecting the value of h_{eff} are possible [K39] When h_{eff} is reduced and frequency is not changed, energy is liberated and the transition proceeds without external energy feed (NMP might pose restrictions). Another option is increase of h_{eff} and reduce the frequency in such a way that single particle energies are not changed. One can imagine many other possibilities since also p-adic length scale leading to a change of mass scale could change. A possible biological application is to the problem of understanding how biomolecules find each other in the molecular soup inside cell so that catalytic reactions can proceed. Magnetic flux tubes pairs connecting the biomolecules would be generated in the reconnection of U-shaped tentacle like flux tubes associated with the reactants, and the reduction of h_{eff} for the flux tube pair would contract it and force the biomolecules near each other.

4. The model for cold fusion in TGD Universe relies on a process, which is analogous to quantum phase transition [L6] [K12]. Protons from the exclusion zones (EZs) of Pollack [L4] [L4] are transferred to dark protons at magnetic flux tubes outside EZ and part of dark protons sequences transform by dark weak decays and dark weak boson exchanges to neutrons so that beta stable dark nuclei are obtained with binding energy much smaller than nuclear binding energy. This could be seen as dark nuclear fusion and quantum analog of the ordinary thermal nuclear fusion. The transformation of dark nuclei to ordinary nuclei by h_{eff} reducing phase transition would liberate huge energy if allowed by NMP [K29] and explain the reported biofusion.

5. Energetics is clearly an important factor (in ordinary phase transitions for open system thermal energy feed is present). The above considerations assume that ordinary positive energy ontology effectively applies. ZEO [K29] allows to consider a more science fictive possibility. In ZEO energy is conserved when one considers single zero energy state as a time evolution of positive energy state. If single particle realizes square root of thermodynamics, one has superposition of zero energy states for which single particle states appear as pairs of positive and negative energy states with various energies: each state in superposition respects energy conservation. In this kind of situation one can consider the possibility that temperature increases and average single particle energy increases. In positive energy ontology this is impossible without energy feed but in ZEO it is not excluded. I do not understand the situation well enough to decide whether some condition could prevent this. Note however that in TGD inspired cosmology energy conservation holds only in given scale (given CD) and apparent energy non-conservation would result by this kind of mechanism.

3.3 ZEO Inspired View About Phase Transitions

This section begins with questions related to TGD based description of phase transitions, discusses the TGD view about the role of symmetries in phase transitions, and asks what new ZEO can give to the description of phase transitions.

3.3.1 Question related to TGD inspired description of phase transitions

The natural questions are for instance following ones.

1. The general classification of thermodynamical phase transitions is in terms of order: the order of the lowest discontinuous derivative of the free energy with respect to some of its arguments. In catastrophe theoretic description one has a hierarchy of criticalities of free energy as function of control variables (also other behavior variables than free energy are possible) and phase transitions with phase transitions corresponding to catastrophe containing catastrophe.... such that the order increases. For intance, for cusp catatrophe one has lambda-shaped critical line and critical point at its tip. Thom's catastrophe theory description is mathematically very attractive but I think that it has problems at experimental side. It indeed applies to flow dynamics defined by a gradient of potential and thermodynamics is something different.

   In TGD framework the sum of Kähler function defined by real Kähler action in Euclidian space-time regions and imaginy Kähler action from Minkowskian space-time regions defining a complex quanty replaced free energy. This is in accordance with the vision that quantum TGD can be seen as a complex square root of thermodynamics. Situation is now infinite-dimensional and catastrophe set would be also infinite-D. The hierarchy of isomorphic superconformal algebras defines an infinite hierarchy of criticalities with levels labelled by Planck constants and catastrophe theoretic description seems to generalize.

   Does this general description of phase transitions at the level of dark magnetic body (field body is more general notion but I will talk about magnetic body (MB) in the sequel) allow to understand also thermodynamical phase transitions as being induced from those for dark matter at MB?

2. Quantum TGD can be formally regarded as a square root of thermodynamics. Does this imply "thermal holography" meaning that single particle states can represent ensemble state as square root of the thermal state of ensemble. Could one unify the notions of thermal and quantum phase transition and include also the phase transitions changing h_{eff}? Could MB make this possible?

3. How does the TGD description relate to the standard description? TGD predicts that conformal gauge symmetries correspond to a fractal hierarchy of isomorphic conformal sub-algebras. Only the lowest level with maximal conformal symmetry matters in standard theory. Are the higher "dark" levels something totally new or do they appear in the description of also ordinary phase transitions? What is the precise role of symmetries and symmetry changes

in TGD description and is this consistent with standard description. Here the notion of field body is highly suggestive: the dynamics of field body could induce the dynamics of ordinary matter also in phase transitions.

There is a long list of questions related to various aspects of TGD based description of phase transitions.

1. In TGD framework NMP applying to single system replaces second law applying to ensemble as fundamental description. Second law follows from the randomness of the state function reduction for ordinary matter and in long length and time scales from the ultimate occurrence of state function reductions to opposite boundary of CD in ensemble. How does this affect the description of phase transitions? NMP has non-trivial implications only for dark matter at MB since it NMP does favor preservation and even generation of negentropic entanlement (NE). Does NMP imply that MB plays a key role in all phase transitions?

2. Does strong form of holography of TGD reduce all transitions in some sense to this kind of 2-D quantum critical phase transitions at fundamental level? Note that partonic 2-surfaces can be seen as carriers of effective magnetic charges and string world sheets carrying spinor modes accompany magnetic flux tubes. Could underlying conformal gauge symmetry and its change have practical implications for the description of all phase transitions, even 3-D and thermodynamical phase transitions?

3. Could many-sheetedness of space-time - in particular the associated p-adic length scale hierarchy - be important and could one identify the space-time sheets whose dynamics controls the transition? Could the fundamental description in terms of quantum phase transitions relying on strong form of holography apply to all phase transitions? Could dark phases at MB be the key to the description of also ordinary thermodynamical phase transitions? Could one see dark MB as master and ordinary matter as slave and redue the description of all phase transitions to dark matter level.

   Could the change of h_{eff} for dark matter at field body accompany any phase transition - even thermodynamical - or only quantum critical phase transition at some level in the hierarchy of space-time sheets? Or are also phase transitions involving no change of h_{eff} possible? Do ordinary phase transitions correspond to these. What is the role of h_{eff} changing "transitons" and their dynamical symmetries?

4. The huge vacuum degeneracy of Kähler action implies that any space-time surface with CP_2 projection that is Lagrangian manifold and has therefore dimension not larger than two, is vacuum extremal. The small deformations of these vacuum extremals define preferred extremals. One expects that this vacuum degeneracy implies infinite number of ground states as in the case of spin glass (magnetized system consisting of regions with different direction of magnetization). One can speak of 4-D spin glass. It would seem that the hierarchy of Planck constants labelling different quantum phases and the phase transitions between these phases can be interpreted in terms of 4-D spin glass property? Besides phases one would have also phase transitions having "transitons" as building bricks.

   It seems that one cannot assign 4-D spin glass dynamics to MB. If magnetic flux tubes are carriers of monopole flux, they cannot be small local deformations of vacuum extremals for which Kähler form vanishes. Hence 4-D spin glass property can be assigned to flux tubes carrying vanishing magnetic flux. Early cosmology suggests that cosmic strings as infinitely flux tubes having 2-DCP_2 projection and carrying monopole flux are deformed to magnetic flux tubes and suffer topological condensation around vacuum extremals and deform them during the TGD counterpart of inflationary period.

   Remark: Glass state looks like a transition rather than state and ZEO and 4-D spin glass description would seem to fit naturally to his situation: glass would be a 4-D variant of spin glass. The time scale of transition is long and one might think that h_{eff} at the space-time sheet "controlling" transition is rather large and also the change of h_{eff} is large.

3.3.2 Symmetries and phase transitions

The notion of symmetry is considerably more complex in TGD framework than in standard picture based on positive energy ontology. There are dynamical symmetries of dark matter states located at the boundaries of CD. For space-time sheets describing phase transitions there are also dynamical symmetries but they are different. In standard physics one has just states and their symmetries. Conformal gauge symmetries forming a hierarchy: conformal field theories this symmetry is maximal and the hierarchy is absent.

1. There is importance and very delicate difference between thermal and thermodynamical symmetries. Thermal symmetries are due to thermal equilibrium implying symmetries in *statistical sense*. Quantal symmetries correspond to representations of symmetry group and are possible if thermal fluctuations do not transform the states of the representations the states of other representation.

   Dark dynamical symmetries are quantum symmetries. The breaking of thermal translational symmetry of liquid leads to discrete translational symmetry of crystal having interpretation as quantum symmetry. The generation of continuous thermal translational symmetry from discrete quantum symmetry means loss of quantum symmetry. To my opinion, standard thinking is sloppy here.

2. For thermodynamical phase transitions temperature reduction induces spontaneous breaking of symmetry: consider only liquid-to-crystal transition. Analogously, in gauge theories the reduction gauge coupling strength leads to spontaneous symmetry breaking: quantum fluctuations combine representation of sub-group to a representation of larger group. It would seem that spontaneous symmetry breaking actually brings in a symmetry and the ubroken symmetry is "thermal" or pure gauge symmetry. QCD serves as an example: as strong coupling strength (analogous to temperature) becomes large confinement occurs and color symmetry becomes pure gauge symmetry.

3. In TGD the new feature is that there are two kinds of symmetries for dark conformal hierarchies. Symmetries are either pure gauge symmetries or genuine dynamical symmetries affecting the dark state at field body physically. As h_{eff} increases, the conformal pure gauge symmetry is reduced (the conformal gauge algebra annilating the states becomes smaller) but dynamical symmetry associated with the degrees of freedom above measurement resolution increases. In ordinary conformal theories pure gauge conformal symmetry is always maximal so that this phenomenon does not occur.

   The intuitive picture is that the increase of dynamical symmetry induced by the reduction of pure gauge conformal symmetry occurs as temperature is lowered and quantum coherence in longer scales becomes possible. This conforms with the thermodynamical and gauge theory views if pure gauge symmetry is identified as counterpart of symmetry as it is understood in thermodynamics and gauge theories.

   The dynamical symmetry of dark matter however increases. This symmetry is something new and would be genuine quantum symmetry in the sense that quantum fluctuations respect the representations of this group. The increase of h_{eff} indeed implies reduction of Kähler coupling strength analogous to reduction of temperature so that these quantum symmetries can emerge.

4. There is also a dynamical symmetry associated with phase transitions $h_{eff}(f) = m \times h_{eff}(i)$ such that m would define the rank of ADE Lie group G classifying states of "transitons". Lie groups with ranks $n_{eff}(i)$ and $n_{eff}(f)$ would be ranks for the Lie group G in the initial and final states. G would correspond to either gauge (not pure gauge) or Kac-Moody symmetry as also for corresponding dynamical symmetry groups associated with phases.

5. An interesting question relates to Kosterlitz-Thouless Thouless phase transition (see `http://tinyurl.com/yce24jr9`), which is 2-D and for which symmetry is not changed. Could one interpret it as a phase transition changing h_{eff} for MB: symmetry group as abstract group would not change although the scale in which acts would change: this is like taking zoom. The dynamical symmetry group assignable to dark matter at flux tubes would however change but remain hidden.

To sum up, the notion of magnetic (field) body might apply even to the ordinary phase transitions. Dark symmetries - also discrete translational and rotational symmetries - would be assigned with dark MB possibly present also in ordinary phases. The dynamical symmetries of MB would bring a new element to the description. Ordinary phase transitions would be induced by those of MB. This would generalize the vision that MB controls biological body central for TGD view about living matter. In the spirit of slaving hierarchy and TGD inspired vision about quantum biology, ordinary matter would be slave and MB the master and the description of the phase transitions in terms of dynamics of master could be much more simpler than the standard description. This would be a little bit like understanding technical instrument from the knowledge of its function and from control level rather than from the mere physical structure.

3.3.3 Quantum phase transitions and 4-D spin glass energy landscape

TGD has led to two descriptions for quantum criticality. The first one relies on the notion of 4-D spin glass degeneracy and emerged already around 1990 when I discovered the unique properties of Kähler action. Second description relies on quantum phases and quantum phase transitions and I have tried to explain my understanding about it above. The attempt to understand how these two approaches relate to each other might provide additional insights.

1. Vacuum degeneracy of Kähler action is certainly a key feature of TGD and distinguishes it from all classical field theories. Small deformations of the vacua probably induced by gluing of magnetic flux tubes (primordially cosmic strings) to these vacuum space-time sheets deforms them slightly and would give rise to TGD Universe analogous to 4-D spin glass. The challenge is to relate this description to the vision provided by quantum phases and quantum phase transitions.

2. In condensed matter physics one speaks of fractal spin glass energy landscape with free energy minima inside free energy minima. This landscape obeys ultrametric topology: p-adic topologies are ultra metric and this was one of the original motivations for the idea that p-adic physics might be relevant for TGD. Free energy is replaced with the sum of Kähler function - Kähler action of Euclidian space-time regions and imaginary Kähler action from Minkowskian space-time regions.

3. In the fractal spin glass energy landscape there is an infinite number of minima of free energy. The presence of several degenerate minima leads to what is known as frustration. In TGD framework all the vacuum extremals have the same vanishing action so that there is infinite degeneracy and infinite frustration (also created by the attempt to understand what this might imply physically!). The diffeomorphisms of M^4 and symplectic transformations of CP_2 map vacuum extremals to each other and acts therefore as gauge symmetries. Symplectic transformations indeed act as U(1) gauge transformations. Besides this each Lagrangian sub-manifold of CP_2 defines its own space of vacuum-extremals as orbit of this symplectic group.

   As one deforms vacuum extremals slightly to non-vacuum extremals, classical gravitational energy becomes non-vanishing and Kähler action does not vanish anymore and the above gauge symmetries become dynamical symmetries. This picture serves as a useful guideline in the attempts to physically interpret. In TGD inspired quantum biology gravitation plays indeed fundamental role (gravitational Planck constant h_{gr}).

4. Can one identify a quantum counterpart of the degeneracy of extremals? The notion of negentropic entanglement (NE) is cornerstone of TGD. In particular, for maximal negentropic entanglement density matrix is proportional to unit matrix so that states are degenerate in the same sense as the states with same energy in thermodynamics. Energy has Kähler function as analogy now: hence the degeneracy of density matrix could correspond to that for Kähler function. More general NE corresponds to algebraic entanglement probabilities and allows to identify unique basis of eigenstates of density matrix. NE is favored by NMP and serves key element of TGD inspired theory of consciousness.

   In standard physics degeneracy of density matrix is extremely rare phenomenon as is also entanglement with algebraic entanglement probabilities. These properties are also extremely

unstable. TGD must be somehow special. The vacuum degeneracy of Kähler action indeed distinguishes TGD from quantum field theories, and an attractive idea is that the degeneracy associated with NE relates to that for extremals of Kähler action. This is not enough however: NMP is needed to stabilize NE and this occurs only for dark matter ($h_{eff}/h > 1$ equals to the dimension of density matrix defining NE).

The strong form of holography takes this idea further: 2-D string world sheets and partonic 2-surfaces are labelled by parameters, which belong to algebraic extension of rationals. This replaces effectively infinite-D WCW with discrete spaces characterized by these extensions and allows to unify real and p-adic physics to adelic physics. This hierarchy of algebraic extensions would be behind various hierarchies of quantum TGD, also the hierarchy of deformations of vacuum extremals.

5. In 3-D spin glass different phases assignable to the bottoms of potential wells in the fractal spin energy landscape compete. In 4-D spin glass energy of TGD also time evolutions compete, and degeneracy and frustration chacterize also time evolutions. In biology the notions of function and behavior corresponds to temporal patterns: functions and behaviors are fighting for survival rather than only organisms.

   At quantum level the temporal patterns would correspond to phase transitions perhaps induced by quantum phase transitions for dark matter at the level of magnetic bodies. Phase transitions changing the value of h_{eff} would define correlates for "behaviors" and the above proposed description could apply to them.

6. Conformal symmetries (the shorthand "conformal" is understood in very general sense here) allow to understand not only quantum phases but also quantum phase transitions at fundamental level and "transitons" transforming according to representations of Kac-Moody group or gauge group assignable to the inclusion of hyperfinite factors characterized by the integer m in $h_{eff}(f) = m \times h_{eff}(i)$ could allow precise quantitative description. Fractal symmetry breaking leads to conformal sub-algebra isomorphic with the original one

   What could this symmetry breaking correspond in spin energy landscape? The phase transition increasing the dynamical symmetry leads to a bottom of a smaller well in spin energy landscape. The conformal gauge symmetry is reduced and dynamical symmetry increased, and the system becomes more critical. Indeed, the smaller the potential well, the more prone the system is for being kicked outside the well by quantum fluctuations. The smaller the well, the large the value of h_{eff}. At space-time level this corresponds to a longer scale. At the level of WCW (4-D spin energy landscape) this corresponds to a shorter scale.

3.3.4 What ZEO can give to the description of criticality?

One should clarify what quantum criticality exactly means in TGD framework. In positive energy ontology the notion of state becomes fuzzy at criticality. It is difficult to assign long range fluctuations and associated quanta with any of the phases co-existent at criticality since they are most naturally associated with the phase change. Hence Zero Energy Ontology (ZEO) might show its power in the description of (quantum) critical phase transitions.

1. Quantum criticality could correspond to zero energy states for which the value of h_{eff} differs at the opposite boundaries of causal diamond (CD). The space-time surface between boundaries of CD would describe the transition classically. If so, then quanta for long range fluctuations would be genuinely 4-D objects - "transitons" - allowing proper description only in ZEO. This could apply quite generally to the excitations associated with quantum criticality. Living matter is key example of quantum criticality and here "transitons" could be seen as building bricks of behavioral patterns. Maybe it makes sense to speak even about Bose-Einstein condensates of "transitons".

2. Quantum criticality would be associated with the transition increasing $n_{eff} = h_{eff}/h$ by integer factor m or its reversal. Large h_{eff} phases as such would not be quantum critical as I have sloppily stated in several contexts earlier. $n_{eff}(f) = m \times n_{eff}(i)$ would correspond to a phase having longer long range correlations as the initial phase. Maybe one could

say that at the side of criticality (say the "lower" end of CD) the $n_{eff}(f) = m \times n_{eff}(i)$ excitations are pure gauge excitations and thus "below measurement resolution" but become real at the other side of criticality (the "upper" end of CD)? The integer m would have clear geometric interpretation: each sheet of n_i-fold coverings defining space-time surface with sheets co-inciding at the other end of CD would be replaced with its m-fold covering. Several replications of this kind or their reversals would be possible.

3. The formation of m-fold covering could be also interpreted in terms of an inclusion of hyperfinite factors labelled by integer m. This suggests a deep connection with symmetries of dark matter. Generalizing the McKay correspondence between finite subgroups of SU(2) characterizing the inclusions and ADE type Lie groups, the Lie group G characterizing the dynamical gauge group or Kac-Moody group for the inclusion of HFFs characterized by m would have rank given by m (the dimension of Cartan algebra of G).

   These groups are expected to be closely related to the inclusions for the fractal hierarchy of isomorphic sub-algebras of super-symplectic subalgebra. $h_{eff}/h = n$ could label the sub-algebras: the conformal weights of sub-algebra are n-multiples of those of the entire algebra. If the sub-algebra with larger value of n_{eff} annihilates the states, it effectively acts as normal subgroup and one can say that the coset space of the two super-conformal groups acts either as gauge group or (perhaps more naturally) Kac-Moody group. The inclusion hierarchy would allow to realize all ADE groups as dynamical gauge groups or more plausibly, as Kac-Moody type symmetry groups associated with dark matter and characterizing the degrees of freedom allowed by finite measurement resolution.

4. If would be natural to assign "transitions" with light-like 3-surfaces representing parton orbits between boundaries of CD. I have indeed proposed that Kac-Moody algebras are associated with parton orbits where super-symplectic algebra and conformal algebra of light-one boundary is associated with the space-like 3-surfaces at the boundaries of CD. This picture would provide a rather detailed view about symmetries of quantum TGD.

The number-theoretic structure of h_{eff} reducing transitions is of special interest.

1. A phase characterized by $h_{eff}/h = n_{eff}(i)$ can make a phase transition only to a phase for which $n_{eff}(f)$ divides $n_{eff}(i)$. This in principle allows purely physics based method of finding the divisors of very large integers (gravitational Planck constant $\hbar_{gr} = GMm/v_0 = \hbar_{eff} = n \times \hbar$ defines huge integer).

2. In TGD inspired theory of consciousness a possible application is to a model for how people known as idiot savants unable to understand what the notion of prime means are able to decompose large integers to prime factors [K44]. I have proposed that the division to prime factors is a spontaneous process analogous to the splitting of a periodic wave characterized by wave length $\lambda/\lambda_0 = n_i$ to a wave with wavelength $\lambda/\lambda_0 = n_{eff}(f)$ with $n_{eff}(f)$ a divisor of $n_{eff}(i)$. This process might be completely spontaneous sequence of phase transitions reducing the value of n_{eff} realized geometrically as the number of sheets of the singular covering defining the space-time sheet and somehow giving rise to a direct sensory percept.

3.4 Maxwell's lever rule and expansion of water in freezing: two poorly understood phenomena

The view about condensed matter as a network with nodes identifiable as molecules and bonds as flux tubes is one of the basic predictions of TGD and obviously means a radical modification of the existing picture. In the sequel two old anomalies of standard physics are explained in this conceptual framework.

3.4.1 Maxwell's lever rule as an indication for the presence of magnetic flux tubes

Van der Waals equation of state (`http://tinyurl.com/yayjgehm`) is a simple model for two phase system used for mostly pedagogical purposes. The model is not realistic. In particular, it has difficulties in the critical region, where two phases are present. The latter difficulties are actually encountered also in the partition function approach of statistical mechanics.

1. Van der Waals equation of state

Consider first the van der Waals equation of state.

1. Van der Waals equation of state has variables (n, T) so that the natural thermodynamical function is free energy F. The equation is of form

$$P = (\frac{\partial F}{\partial V})_T = \frac{n}{1-nb_1}T - a_1 n^2 \quad . \tag{3.1}$$

   Here one has $n = N/V$, where N is particle number and constant parameter. $(b_1 = 0, a_1 = 0)$ gives the equation of state for ideal gas. The interpretation of the parameters is discussed in `http://tinyurl.com/yayjgehm`.

2. To deduce free energy F and internal energy E one would need also the partial derivative of free energy

$$S = (\frac{\partial F}{\partial T})_V \quad , \tag{3.2}$$

   so that $dF = SdT - pdV$ could be integrated. The information about entropy is not included in van der Waals.

3. The expressions of both E and F can be fixed by assuming that E is a homogenous funktion of (S, T, P, V):

$$E = TS - PV \quad . \tag{3.3}$$

   This is additional assumption, which of course need not be true.

   (a) The assumption would give for the free energy per particle the expression

$$f = \frac{F}{N} = \frac{E - TS}{N} = \frac{PV}{N} = \frac{P}{n} \tag{3.4}$$

   In the case of van der Waals one obtains by using the expression for the pressure already given

$$f = \frac{P}{n} = \frac{T}{1-nb_1} - a_1 n \quad . \tag{3.5}$$

   (b) The entropy per particle is given by

$$s = \frac{S}{N} = \frac{(\frac{\partial p}{\partial T})_V}{n} = \frac{1}{1-nb_1} \quad . \tag{3.6}$$

   $s = S/N$ does not depend on temperature at all.

   (c) For single particle energy $e = E/N$ one has

$$e = \frac{TS-PV}{N} = a_1 n \quad . \tag{3.7}$$

   Also e depends on n only.

4. Van der Waals indeed allows 2 phases and they appear simultaneously in the critical region. The equation of state can be written as a condition for the vanishing of 3rd degree polynomial $P_3(n,T)$ as a function of n

$$\begin{array}{lll} P_3(n,t) = \sum_{k=0}^{3} p_k^{n^k} = 0 & p_3 = 1 \ , & p_2 = -\frac{1}{b_1} \ , \\ p_1 = \frac{P}{a_1 b_1} + \frac{T}{a_1 b_1} \ , & p_0 = -\frac{P}{a_1 b_1} \ . & \end{array} \tag{3.8}$$

   The number of the real roots for n is odd: either 3 or 1. In the critical region, which corresponds to a cusp catastrophe (see `http://tinyurl.com/ngfa9t3`) having n as behaviour variable, the number of real roots is 3, call them $n_{max} \geq n_0 \geq n_{min}$. The largest root n_{max} and smallest root n_{min} correspond to liquid and gas phases. The middle root n_0 is unstable if the polynomial equation is interpreted as a vanishing of the derivative of a fourth-order polynomial of n having p and T as control parameters. It has no physical identification.

   The projection of the cusp (see `http://tinyurl.com/ngfa9t3`) to (p,T) has shape of V with curved edges. The tip of V corresponds to critical point and at the edges of V a phase transition takes place between vapour phase and critical phase or liquid phase and critical phase. Above the tip one cannot say whether the phase is gas or liquid and the continuous transformation of gas to liquid can be also regarded as poorly understood.

   At the right (left) hand side of V there is single real root n_G (n_L). $n_G < n_L$ allows the interpretation in terms of gas and liquid phases.

2. The problems of van der Waals

Consider now the problems of van der Waals in the critical region.

1. Van der Waals allows besides gas phase also liquid phase but the model does now work well in liquid phase. In the critical region where both gas and liquid phases are possible, the model works badly. Equation of state forces the system to a 2-dimensional surface in (n,p,T) space ($n = N/V$, also V can be used as variable since N is constant parameter).

   The standard interpretation is that both phases are present as pure phases and only their fractions vary. The intermediate phase allowed by van der Walls is not present. The empirical finding that the pressure for given temperature does not depend on V. $p(V,T) = p(T)$ condition states that the pressures of the two phases are same: this can be interpreted as equilibrium condition. It follows from van der Waals naturally for different roots n for the equation of state.

2. Already Maxwell proposed a modification of van der Waals. Area rule (for a visualization see `http://tinyurl.com/ycabjdhh`) tells how the oscillatory behaviour of $p(T,V)$ as function of V as one moves in transversal direction (in which p varies) to V along cusp from lowest sheet of cusp (n_-) to the highest sheet (n_+) by increasing V is replaced with constant behavior. In other words, the curve along cusp connecting constant T curves connecting the points at upper and lower sheet of cusp with the same value of p is replaced with a straight vertical line. The condition is that the area below the line is same as the area below the oscillatory curve of constant p.

   Lever rule (`http://tinyurl.com/ybuq7aye`) is needed to understand the proportions of the two phases. Usually the rule is applied to metal alloys. Consider two pure phases α ja β and their mixture γ. Let the fractions of phases α and β be X_α and X_β. Assume that the phases contain two "elements" A and B. Let the proportions of B be a in α, b in β and c in γ. The lever rule

$$X_\alpha = \frac{c-b}{a-b} \tag{3.9}$$

   follows trivially from the fact that in mixed phase γ one has $c = X_\alpha a + (1 - X_\alpha b = X_\alpha(a-b) + b$.

In critical regions a and b should vary. To me this picture however represents a problem. What the two "elements" are in the case of say water? If water molecule corresponds to A, what does B correspond to? A different state of water molecule? Or does the system contain also some other "element" than water molecule?

As a consequence of this problem the working models are numerical since analytical models cannot explain the lever rule. This problem is not only the problem of van der Waals but quite general problem of statistical models relying on partition function giving free energy F.

3. TGD based explanation of the lever rule

The TGD interpretation for the situation could be following.

1. In the liquid phase molecules can be connected by flux tubes. They are also possible in gas phase but their number is smaller. In particular, in vapour phase intermediate between liquid and gas also gas molecules can be connected by flux tubes to form connected networks.Only single connected network could be present in liquid phase.

   The number of flux tubes per particle can depend on the thermodynamical parameters (V, T) and is expected to be considerably smaller in gas phase in regions where one can distinguish liquid phase from vapor phase (not below the tip of V).

   In liquid state the flux tubes could be shorter than in gas phase. In liquid phase there are large connected structures - maybe only single one - whereas in gas phase these structures are smaller. At criticality they might correspond to vapour droplets. Gas phase would be different from gas phase far from criticality.

2. In critical region there are regions, which form connected networks differing with respect to the number of bonds per particle characterizing the networking. The volume of the mixed phase depends on the relative volumes of these two phases since they have widely differing densities. Large number of networked molecules gives a smaller volume. The pressures in these two kinds of regions are same in mechanical equilibrium.

3. What could be the counterparts for the two "elements" A and B? Could A correspond water molecule and B to flux tube? The portion of flux tubes would distinguish between the two phases at criticality. They are present also in gas phase unless one has $b = 0$ identically. In this case a must however vary inside critical region. For $b = 0$, perhaps realized far from the left edge of V, gas phase would have no flux tubes. In liquid phase to the right from V but not below the tip of V a would be large. At tip and below it one would have $a = b$ along some line and one can say that gas phase transforms to liquid phase. As one goes around the tip the fraction a in liquid phase becomes b for gas phase.

4. What distinguishes liquid and gas phases? What suggests itself is that when the number N_b of flux tube bonds per molecule is above critical value $N_{b,crit}$, a transition to liquid phase takes place and the density is reduced to that of liquid. Below the tip of V and left to V this phase transition does not take place. To the right of the edge of we it would take place. Inside V there are both kinds of regions. What this means that the parameters a and b are new parameters characterizing the state of liquid and gas phases. This could allow better understanding of vapour phase.

5. The appearance of flux tubes could be understood in two ways. .

   (a) New flux tube pairs could emerge by reconnection of flux tube loops associated with molecules.

   (b) Already existing long flux tubes (or flux tube pairs) between molecules shorten in a phase transition reducing $h_{eff} = n \times h$ to its standard value and forces the molecules connected by them to become close together. Since the phases with non-standard value of Planck constant quite generally have higher energy (for instance, bond energies are higher and atomic binding energies lower) this implies that energy is liberated in this connection process.

It seems that flux tube picture could explain the lever rule, which works but cannot be understood in thermodynamics and statistical physics. This would be seen as a direct indication for the reality of flux tubes.

3.4.2 Strangeness in the freezing of water

Water has hundreds of anomalies as one learns from the excellent web pages of Martin Chaplin (see `http://www1.lsbu.ac.uk/water/`). I have discussed these anomalies in [K18]. One of them relates to the freezing of water. Usually the volume per particle is reduced in freezing but now it increases. Second biologically enormously important anomaly is the decrease of the molecular volume instead of increase as the temperature grows form 0 °C to 4 °C.

In TGD framework the anomalies of water can be seen as a support for the existence of two phases in water: dark phase identified as a phase with non-standard value $h_{eff}/h = n$ of Planck constant [**?**] and ordinary phase. On basis of the model explaining Maxwell's rule at criticality, one can ask whether the dark and ordinary phases correspond to those for the flux tubes rather than molecules. In the case of water the flux tubes could be assigned to hydrogen bonds, which could have quite long lengths for large values of $h_{eff}/h = n$. They would be present also for other liquids. Maybe the flux tubes carrying $h_{eff}/n = n$ dark protons associated with hydrogen bonds distinguish water from other liquids.

Dark states have higher energy than ordinary ones so that the formation of dark phase requires energy. The natural assumption is that the dark phase transforms to ordinary one in the freezing of water. Long dark flux tubes would get shorter. Alternatively, dark flux loops reconnect and form short flux tube pairs between molecules assignable to hydrogen bonds. Why this should lead to an expansion of the molecular volume?

To answer this question it is useful consider first the second anomaly. Why the volume increases as one reduces temperature from 4 °C to 0 °C? As $h_{eff}/h = n$ for flux tube or reconnecting flux tubes decreases, the length of flux tube as quantal length shortens and the result could be a rather rigid short stick. There exists a proposal that these rigid flux tubes reduce the motility of water molecules belonging to the water clusters, which correspond to connected flux tube networks. Since molecules cannot move freely anymore, empty volume is generated. The outcome is an increase of the average molecular volume.

What about freezing?

1. Above boiling point water has 3.4 hydrogen bonds to its neighbors, which is nearly the maximal number 4 realized for ice (see `http://tinyurl.com/ydcedet4`). Either all existing long flux tubes would have shortened or all loops would have shortened and reconnected to flux tube pairs.

2. In freezing the dark energy is liberated so that the latent heat should be higher when a phase with a non-standard value of $h_{eff}/h = n$ is present in the liquid phase. This could explain the especially high latent heat 334 kJ/kg for water.

3. Only ammonia NH^3 (see `http://tinyurl.com/yc6zcl6o`) has comparable latent heat 332.17 kJ/kg (see `http://tinyurl.com/h3lvm43`) . Interestingly, also NH_3 molecules form hydrogen bonds and for this reason ammonium is easily miscible to water. This property might relate also to the biological importance of NH_3 and nitrogen and hydrogen containing molecules.

4. Also O and F form hydrogen bonds. More generally, any atom containing lone electron pairs, that is pairs of valence electrons, which do not belong to valence bonds, can form hydrogen bonds. A possible explanation is that the lone pair goes to a flux tube pair associated with the hydrogen bond and gives rise to a Cooper pair making possible high T_c superconductivity by the mechanism discussed in [K40, K41]. Flux tube pair would contain also the dark proton delocalized to both flux tubes.

3.5 TGD based view about ferromagnetism

I received a link to a highly interesting popular article (`https://tinyurl.com/y8b86df3`) about ferromagnetism. According to the article, Yi Li, a physicist working at John Hopkins University

and his two graduate students, Eric Bobrow and Keaton Stubis, seem to have made a considerable progress in understanding how the system of electron spins in lattice ends up to a ferromagnetic sate [D8] (`https://tinyurl.com/y9ycj3nt`). This ferromagnetism is known as itinerant ferromagnetism and involves vacancies, sites without electron, which can be moved freely without affecting the energy of the state. This article inspired train of thought allowing to develop TGD view about ferromagnetism.

3.5.1 The ideas related to the work of Li *et al*

The problem considered by Li *et al* is how the ferromagnetic state could emerge from an arbitrary state with some numbers of spin up and spin down states at lattice sites connected by edges.

1. Permutation of electrons with same spin leave the ferromagnetic state invariant and does not cost energy while permutations in arbitrary configuration can do so.

2. Li *et al* [D8] considered a simple 4×4 lattice with single vacancy and noticed a connection with so called 15-puzzle involving 15 tiles and single vacancy with neighboring tiles of vacancy able to move to its position. The observation is following. If one has spin lattice containing single vacancy, one can number the sites by a number running from 1 to N (now 15) in arbitrary manner. If so called connectedness condition holds true one can realize any permutation of these numbers. This means that 15-puzzle has always a solution. In particular, one can arrange the situation that the numbers form an ordered sequence from 1 to N so that numbers n and $n+1$ are nearest neighbors.

   The result found by Li *et al* first for 2-D 4×4 lattice with single vacancy generalizes to lattices, which are non-separable in the sense the removal of a lattice site does not separate any pair of spins - they are still connected by an edge-loop.

3. The curve solving the 15-puzzle goes through all points of the 4×4 lattice and is generally known as Hamiltonian curve. It becomes Hamiltonian cycle if the numbers 1 and N are nearest neighbors.

4. The basic problem of this approach is that the theorem is true only for single vacancy and does not allow generalization to a larger number of vacancies. It is however known that ferromagnetism is possible up to fraction 1/3 for vacancies. The challenge is to generalize the result of Li *et al*.

3.5.2 Some reasons to get interested

In TGD framework there are good reasons of getting interested on these results.

1. The result of Li *et al* states that ferromagnetic phase transition might be understood in terms of shifting of lattice vacancy if the lattice with single defect allows deformation of any configuration of spin labelled by numbers N running from 1 to N to a closed curve connecting nearest neighbors along which N increases. Could there be a connection with Hamiltonian curves making sense for lattice like structures (actually all graphs)? Could Hamiltonian curve have some deeper physical meaning or is it only an auxialiary notion useful for representing the possibility to realize all permutations for the points of a lattice with vacancy by shifting it suitably?

   Hamiltonian curve connects neighboring points of a lattice and goes through all points without self-intersections. Icosahedral geometry appears in biology and one can ask whether this kind of cycles could be actually realized physically - say as flux tubes at icosahedron and tetrahedron, which play key role in TGD inspired biology. Flux tube are actually fundamental objects in TGD Universe in all scales. For instance, final states of stars could correspond to flux tube spaghettis consisting of single volume filling flux tube [L38] (`https://tinyurl.com/tkkyyd2`).

2. If the Hamiltonian cycle is something physical it could correspond to flux tube. The notion of magnetic flux tube central in TGD might allow application to ferromagnetism. TGD

predicts two kinds of flux tubes: Maxwellian ones and monopole flux tubes with magnetic fields requiring no currents to generate them: they are not not allowed by Maxwell's theory.

The preservation of the Earth's magnetic field predicted to decay rather rapidly as currents generating it dissipate supports the view that it contains monopole flux part which from biological input would correspond to endogenous magnetic field B_{end}, which is a fraction 2/5 about the nominal value of $B_E = .5$ Gauss. The presence of magnetic fields in cosmological scales is also a mystery finding a solution in terms of monopole flux tubes.

3. Monopole flux tubes must be closed. Closed non-intersecting flux tubes connecting nearest neighbors in lattice would correspond to Hamiltonian cycles. In TGD inspired biology Hamiltonian cycles associated with icosahedron and tetrahedron provide a realization of the vertebrate genetic code [L2] (`https://tinyurl.com/yad4tqwl`) but it is still somewhat of mystery why the points of icosahedron and tetrahedron, which are lattices (tessellations) at sphere, would be connected by a curve. Quantum classical correspondence suggests that magnetization corresponds to flux tubes connecting magnetic dipoles as formal analogs of monopole-antimonopole pairs. Could magnetic flux tubes provide a concrete realizaon for these Hamiltonan cycles?

4. Closed monopole flux tubes seem to be unrealistic for the description of ferromagnetism, which suggests the presence of N parallel flux tubes carrying magnetization M and defining a braid connecting opposite ends of ferromagnet. The monopole fluxes could arrive as single flux along parallel space-time sheet carrying field H defined by single thick flux tube. Test particle would experience $B = M + H$.

The following considerations are not much more than first impressions and probably require updating.

3.5.3 TGD based view

Flux tubes are the new element of condensed matter physics predicted by TGD. Could they provide insights into ferromagnetism?

1. Starting from text book picture about ferromagnetism

To develop TG view about ferromagnetism it is best to start from the text book picture.

1. In the standard model of ferromagnetism one assumes the presence of field B identified as sum $B = M + H$ of magnetization and field H equal to B outside the magnet. M is due to magnetic dipoles besides magnetic field B and the interaction of spins with H is important. B is usually regarded as the fundamental field M and and H appear as auxiliary notions and their relation to B requires a model for the system: typically H, M, and B are assumed to be linearly related.

2. The field M could be naturally assigned with a flux tube connecting the spins - perhaps at nearest neighbor lattice points. What about H? In standard model H and B are parallel for the ferromagnetic configuration. If B is assigned with the flux tube connecting the magnetic moments and B is parallel to H, this would suggest a flux tube consisting of long straight portions parallel to each other.

   In the many-sheeted space-time of TGD M and H can reside at different space-time sheets, which are parallel so that they are on top of each other in $H = M^4 \times CP_2$. H is at large space-time sheet including also the environment. The decomposition to sum would have representation as a set theoretic union.

   The test particle would experience the sum of the magnetic fields associated with the two sheets. Could M and H as the return flux associated with M and superposing with the external contribution to H correspond to these two space-time sheets so that particle would experience their sum as $B = M+H$? If so, ferromagnetism could be seen as a direct signature of many-sheeted space-time.

2. Could also monopole flux tubes be important?

There is still one important aspect related to the TGD view about magnetic field which might play important role. TGD predicts two kind of flux tubes. The first kind of flux tubes could be called Maxwellian and the corresponding magnetic fields require current to generate them. There are also flux tubes having closed cross section and carrying monopole fluxes. No currents are required to generate corresponding magnetic fields. Could also these flux tubes having no current as sources be present? This would mean new physics.

1. The first thing to notice is that the interpretation of magnetization M is as a magnetic field generated by magnetic moments. The usual interpretation is that spins are analogous to magnetic moments created by currents consisting of rotating charge. For spin there is no such rotating charge. Second interpretation is as magnetic moments identifiable as infinitesimal monopole pairs.

2. Could one think that the flux tubes containing sequence magnetic moments correspond to monopole flux and that closing this loop could give rise to monopole magnetic field? Ordinary Maxwellian part could be also present and have current as source. How M and H would relate to these. Could M correspond to the monopole part and H the Maxwellian part?

   Are spins necessary for the existence of a monopole flux tube? Could quantum classical correspondence require this? Could dark charged matter assigned with the monopole flux tubes correspond to the magnetic moments of say dark valence electrons with non-standard value of $h_{eff} = nh_0$ so that M would be represented by monopole flux tubes classically? If the return flux represented by H is absent, flux tube must give rise to a Hamiltonian cycle. If H is present, it would be enough to have flux tubes representing N braid strands fusing to single monopole flux carrying the return flux.

   Formation of a flux loop defining Hamiltonian cycle would be a new kind of phenomenon analogous to spontaneous magnetization requiring no external field H. Spontaneous magnetization would be however something different. A trivial braid consisting of N parallel strands representing M and parallel to it locally with return flux arriving along single large flux tube carrying H would be formed in ferromagnetic transition and also in spontaneous magnetization.

3. Bringing in thermodynamics

One can try to make this more concrete by bringing in thermodynamics.

1. Assume that there exists single flux tube - connecting all the lattice points (magnetic moments) or possibly N flux tubes parallel to local magnetization M and giving rise to a braid like structure representing the topology of flux lines of M connecting opposite boundaries of magnet.

2. In the general case, the points of the lattice could be connected by a flux tubes connecting points, which need not be nearest neighbors. The first guess is that the magnetic interaction energy of spins at the ends of the flux tube portion connecting them decreases with the distance between spins. There should be also magnetic energy associated with the field H at the space-time sheet carrying the return flux. Thermodynamics would bring in entropy and free energy $F = E - TS$ would be mimimized. Entropy maximization would favor long random flux tubes and energy minimization short flux tubes.

   One expects that flux tube has free energy F increasing with flux tube length. If one does not allow self-intersections - as suggested by repulsive Coulomb interaction and Fermi statistics - the flux tube could be either Hamiltonian cycle or consist of analogs of braid strands: in the case of ferromagnetism the strands would be parallel to each other. The interaction energy would be same for all Hamiltonian cycles if determined by nearest neighbour interactions.

3. In the general case with lattice replaced by graph one expects that a large number of Hamiltonian cycles not related by rotation to each other exists so that one would have large number

of states with same minimum energy. Could this somehow correspond to spin glass state allowing large number of degenerate states? The flux tube need not be closed. In ferromagnetic configuration this would be the case.

4. How would the assignment of spin direction to the lattice points affect the situation? Could the numbers N_+ and N_- of spin up and spin down electrons determine the flux tube configuration (say braid) by (Gibbs) energy minimization?

4. Could 2-braid describe the transition to ferromagnetism?

In the work of Li *et al* discussed in the article, the permutations of lattice points are induced by moving the vacancy around. This picture inspired the considerations above but is too limited. In fact the work of Li *et al* only directed attention to Hamiltonian cycles and braids formed by the non-closed analogs.

1. TGD picture brings in mind braid-knot connection. One can replace the braid associated with M with a knot by connecting the magnetic moments at the opposite ends of the braid by strands of a trivial braid at parallel space-time sheet. This trivial braid would carry the return flux having interpretation in terms of field H.

   The flux tubes of trivial braid could also fuse to single thicker flux tube or flow to a larger space-time sheet carrying the total return flux associated with M. This would conform with the idea that H provides a description of the system in longer length scale being analogous to a smoothed out total magnetic field acting as self-consistent background.

   Remark: Could one assume that only H assignable to big flux tube has constant direction and magnitude and that M is represented as flux tubes connecting dipoles can in principle correspond to any permutation of atoms? For this option the spontaneous magnetization would correspond to a superposition of different configurations with same weights and would be invariant under permutations as in the argument of Li *et al* involving no flux tubes. This option does not look attractive.

2. What braid picture allows to say about the transition to ferromagnetism? Could the transition be realized by deforming the flux tubes associated with M and forming a non-trivial braid be induced by permutation of the lattice points taking the non-trivial braid to trivial one? This would be like opening the braid. The lattice points in the initial and final state would correspond to the ends of a dynamical evolution. The permutation would be realized as a time-like braiding with braid strands in time direction.

   Mathematically braid group corresponds to the covering group of permutation group and quantum group representations correspond to the representations of braid groups. The description of the transition could provide a new application of quantum groups.

The description as time-like braiding is not however complete since there is an additional structure involved: the flux tubes connecting the magnetic dipoles in lattice and defining a braid or even more complex configuration having flux tube connections between non-neighboring magnetic moments.

1. If there is no return flux assignable to H, M corresponds to a closed flux tube carrying monopole flux the dynamical time-like dynamical braiding would lead to a Hamiltonian cycle in this case and the number of final state configurations would be finite, there is degeneracy. Could spin glass phase correspond to this situation?

2. In ferromagnetism final state would contain N parallel strands carrying the monopole flux assignable to M and the return flux H would arrive along parallel thick flux tube. In general configuration these strands can be braided. The transition to ferromagnetism would represent time-like braiding of an ordinary 3-D braiding of flux tube strands connecting the opposite boundaries of ferromagnetic. In the initial state braid would be non-trivial and the flux tubes of braid would not have minimal length and minimum energy. In the final ferromagnetic state braid would be trivial with parallel flux tubes.

Mathematically this process would correspond to what is called 2-braiding: I have proposed that 2-braidings are important in TGD inspired biology as a topological description of dynamical processes. An interesting interpretation is as a topological analog for problem solving. I have also proposed that in bio-systems topological quantum computation programs are represented as this kind 2-braidings for flux tubes [K1, K51] (`https://tinyurl.com/ycvgjccq` and `https://tinyurl.com/ydylud6c`.)

Ferromagnetism would correspond to an opening of a non-trivial braid. If the return flux arrives along flux tubes this is possible smoothly only if the knot defined in this manner is trivial. To achieve opening, the 2-braiding must involve reconnections, which correspond to cutting the knot strand and reconnecting the pieces in new manner: this is how Alexander opened his knot. Fermi statistics and repulsive Coulomb interaction do not favour this mechanism. If the return flux arrives along single flux tube, the opening could correspond to a smooth deformation without reconnections transferring the braiding to the parallel space-time sheet, where it is "neutralized" by fusing the flux tubes to single flux tube.

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   One expects that flux tube has free energy F increasing with flux tube length. If one does not allow self-intersections - as suggested by repulsive Coulomb interaction and Fermi statistics - the flux tube could be either Hamiltonian cycle or consist of analogs of braid strands: in the case of ferromagnetism the strands would be parallel to each other. The interaction energy would be same for all Hamiltonian cycles if determined by nearest neighbour interactions.

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even more complex configuration having flux tube connections between non-neighboring magnetic moments.

1. If there is no return flux assignable to H, M corresponds to a closed flux tube carrying monopole flux the dynamical time-like dynamical braiding would lead to a Hamiltonian cycle in this case and the number of final state configurations would be finite, there is degeneracy. Could spin glass phase correspond to this situation?

2. In ferromagnetism final state would contain N parallel strands carrying the monopole flux assignable to M and the return flux H would arrive along parallel thick flux tube. In general configuration these strands can be braided. The transition to ferromagnetism would represent time-like braiding of an ordinary 3-D braiding of flux tube strands connecting the opposite boundaries of ferromagnetic. In the initial state braid would be non-trivial and the flux tubes of braid would not have minimal length and minimum energy. In the final ferromagnetic state braid would be trivial with parallel flux tubes.

   Mathematically this process would correspond to what is called 2-braiding: I have proposed that 2-braidings are important in TGD inspired biology as a topological description of dynamical processes. An interesting interpretation is as a topological analog for problem solving. I have also proposed that in bio-systems topological quantum computation programs are represented as this kind 2-braidings for flux tubes [K1, K51] (`https://tinyurl.com/ycvgjccq` and `https://tinyurl.com/ydylud6c`.)

   Ferromagnetism would correspond to an opening of a non-trivial braid. If the return flux arrives along flux tubes this is possible smoothly only if the knot defined in this manner is trivial. To achieve opening, the 2-braiding must involve reconnections, which correspond to cutting the knot strand and reconnecting the pieces in new manner: this is how Alexander opened his knot. Fermi statistics and repulsive Coulomb interaction do not favour this mechanism. If the return flux arrives along single flux tube, the opening could correspond to a smooth deformation without reconnections transferring the braiding to the parallel space-time sheet, where it is "neutralized" by fusing the flux tubes to single flux tube.

4 Summary about applications of hierarchy of Planck constants to quantum criticality

During years I have proposed several examples about systems to which I have assigned non-standard value of Planck constant $h_{eff} = n \times h$. If the hypothesis about the connection with criticality is correct they should exhibit criticality and if $h_{eff} = h_{gr}$ hypothesis is true, also phase separation. Also the proposed mechanisms to generate dark matter should involve generation of criticality.

4.1 Particle Physics

In particle physics there are some possible applications for the new view about dark matter.

1. The perturbative expansion of scattering amplitudes in terms of gauge coupling strength or gravitational coupling strength ceases to converge at some critical value of the coupling parameter. This can be regarded as a critical phenomenon since a transition to strongly coupled phase with different properties takes place. For instance, in gauge theories according to the electric-magnetic duality the magnetic monopoles replaces charged particles as natural basic entities. The original proposal indeed was that the transition to large h_{eff} phase takes place when the perturbation theory in terms of say electromagnetic coupling strength $Z_1 Z_2 e^2/\hbar c$ ceases to converge. By replacing h with $h_{em} = Z_1 Z_2/e^2 h_{eff}$ the convergence is achieved and v_0/c replaces gauge coupling strength as coupling constant. A stronger hypothesis is that $h_{eff} = h \times h = h_{em}$ would connect this hypothesis with generalized conformal invariance and its breaking.

2. One of the earliest applications of TGD notion of color (associated not only with quarks and gluons but also leptons through color partial waves) was to explain anomalous production of

electron-positron pairs in heavy ion collisions just above the Coulomb wall [C5, C3, C4, C6]. The TGD inspired hypothesis [K49] was that the electron positron pairs result from the decays of leptopions, which are pion-like color singlet bound states of color octet excitations of electron and positron but one could consider also other options. The identification as positronium is excluded since in this case direct decays would not be kinematically possible. The objection against postulating new elementary light particles is that they should make themselves visible in the decay widths of weak bosons.

One manner to escape the problem is that spartners are heavy so that the decays of weak bosons to spartner pairs are not possible. Another explanation could be that the exotic particles involved correspond to non-standard value of Planck constant. As a matter fact, these particles could be very massive but due to the large value of h_{eff} would appear as effectively massless particles below the scaled-up Compton length.

One can consider also other identifications for the new particles possibly involved. TGD predicts that right handed covariantly constant neutrino generates $\mathcal{N} = 2$ supersymmetry. An elegant universal explanation for the absence of spartners would be that they are heavy but can make themselves visible as dark variants in scales below scaled up Compton length. Maybe the lepto-electrons are selectrons possibly moving in color octet partial wave!

This explanation would apply to all elementary elementary particles and predict that these particles can be produced only in critical systems. This would solve the puzzle created by the non-observation of standard $\mathcal{N} = 1$ SUSY and at LHC. Leptopion production indeed takes place at criticality: just above the Coulomb wall, when the incoming nucleus becomes able to collide directly with the target. It should be noticed that there is experimental evidence also for the leptopions associated with muon and tau [K49].

3. RHIC and later LHC found that the de-confinement phase transition (criticality is obviously involved!) supposed to lead to QCD plasma produced something different. The phase in question has long range correlations and exhibits the presence of string like structures decaying to ordinary hadrons. There is also evidence for strong parity breaking in the system and it is involved with the magnetic fields present [C1]. TGD interpretation could be in terms of a criticality in which long range correlations are generated as dark matter is created. Since strong parity breaking is involved, it seems that the dark particles must be associated with the weak length scale characterized by Mersenne prime M_{89}, which characterizes also the "almost-predicted"! scaled up copy of ordinary hadron physics characterize by Mersenne prime M_{107}. The mass scale is 512 times higher than for ordinary hadrons. Due to darkness the Compton scales of M_{89} hadrons and also weak bosons would be scaled up to about M_{107} p-adic scale if $h_{eff}/h = 2^9$ holds true.

4.2 Condensed Matter Physics

By its nature condensed matter physics provides rich repertoire of critical phenomena.

1. Different phases of same substance, say water, can be in phase equilibrium at criticality and dark matter. There are critical regions of parameter space -critical lines and critical points, in which the transitions between different phases are possible. Long range thermodynamical correlations are associated with these systems and the association with dark matter would suggest that dark matter could appear in these critical systems.

2. Different substances can form mixtures (`http://tinyurl.com/286nqx`). For instance, oil can mix to water in some parameter regions. This kind of systems are good candidates for critical systems. There is actually rich spectrum of mixtures. Solutions (`http://tinyurl.com/yz3hvq`), colloids (`http://tinyurl.com/yabljt8l`), dispersions (`http://tinyurl.com/bq3vm2m`) and the substances can be also in different phases (gas, liquid, solid) so that very rich spectrum of possibilities emerges. Is the generation of dark matter involved only with the phase transitions between different types of mixed phases or between mixed and non-mixed phase? Are some phases like gel inherently critical?

3. One example about criticality is phase transition to super-fluidity or super-conductivity. In the transition from super-conducitivity the value of specific hearts diverges having the shape

of greek letter λ: hence the name lambda point. This suggests that in transition point the specific heat behaves like N^2 due to the quantum coherence instead of proportionality to N as usually. The strange properties of super-fluid, in particular fountain effect, could be understood in terms of $h_{eff} = h_{gr}$ hypothesis as will be discussed.

4.3 Living Matter

Biology is full of critical systems and criticality makes living matter highly sensitive to the external perturbations, gives maximal richness of structure, and makes them quantum coherent in macroscopic scales. Therefore it is not difficult to invent examples. The basic problem is whether the criticality is associated only with the transitions between different systems or with the systems themselves.

1. Sols and gels are very important in biology. Sol is definition a micture solid grains and liquid (say blood of cell liquid). Gel involves fixed solid structure and liquid. Sol-gel phase transition of the cell fluid takes place when nerve pulse travels along axon leading to the expansion of the cell. Is the dark phase generated with the sol-gel transition or does it characterized sol. Perhaps the most logical interpretation is that it is involved with the phase transition.

2. Pollack's fourth phase of water resembles gel [L4]. Charge separation implying that the exclusion zones are negatively charged takes place. Charging takes place because part of protons goes to outside of EZ. TGD proposal is that protons go to magnetic flux tubes outside the region or to flux tubes which are considerably larger than EZ that most of their wave functions is located outside the EZ. Is fourth phase is permanently quantum critical? Or is the quantum criticality associated only with the transition so that magnetic flux tubes would carry protons but they would not be dark after the phase transition. EZs have a strange property that impurities flow out of them. Could the presence of dark flux tubes and $h_{eff} = h_{gr}$ forces the separation of particles with different masses?

3. The chirality selection of bio-molecules is a mystery from the point of view of standard physics. Large h_{eff} phase with so large value of Planck constant that the Compton length of weak bosons defines nanoscale, could explain this: weak bosons would be effectively massless and mediate long range interactions below the scaled up Compton scale. This phase transition could also force phases separation if $h_{gr} = h_{eff}$ holds true. If the masses of biomolecules with different handedness are slightly different also the values of h_{gr} would differ and the molecules would go to flux tubes with different value of h_{eff} - at least in the phase transition. The value of $\hbar_{gr} = GMm/v_0$ is in the range $10^{10} - 10^{11}$ for biomolecules so that the $\Delta n/n \simeq \Delta m/m \simeq 10^{-10} - 10^{-11}$ would be needed: this would correspond to an energy of eV which corresponds to the energy scale of bio-photons and visible light.

4. Neuronal membrane could be permanently a critical system since the membrane potential is slightly above the threshold for nerve pulse generation. Criticality might give rise to the dark magnetic flux tubes connecting lipids to the DNA nucleotides or codons assumed in the model of DNA as topological quantum computer. The braiding of the flux tubes would represent the effect of the nerve pulse patterns and would be generated by the 2-D flow of the lipids of the membrane forming a liquid crystal.

4.4 Fringe Physics

If one wants the label of crackpot it is enough to study critical phenomena. Those who try to replicate (or usually, to non-replicate) the claimed findings fail (or rather manage) easily since criticality implies careful tuning of the external parameters to demonstrate the phenomenon. Therefore the tragedy of fringe physicist is to become a victim of the phenomenon that he is studying.

1. Cold fusion involves bombarding of target consisting of Palladium target doped with deuterium using hydrogen atoms as projectiles. Cold fusion is reported to occur in a critical range of doping fraction. This suggests quantum criticality and large h_{eff} phase. One of the TGD based models generalizes the model of Widom and Larsen [C2]. The model assumes that weak interactions involving emission of W boson neutralizing the incoming proton makes

possible to overcome the Coulomb wall. What would make the system critical? Does criticality make Palladium a good catalyst? Could the Palladium and with a large surface area define nano-scale variant of partonic 2-surface and large area which quite generally would make it effective as catalyst? Certainly this could hold true for bio-catalysts. Could Pd target be permanently in critical state? Effectiveness of catalyst might mean quantum coherence making chemical reaction rates proportional to N^2 instead of N, which could be the number of reactants of particular kind.

2. Di-electric breakdown in given medium occurs when the electric field strength is just above the critical value. A lot of strange claims have been assigned to these systems by non-professionals: in academic environment these phenomena are kind of taboo. Tesla studied them and was convinced that these phenomena involve new physics [K4]. The basic finding was that charges appeared everywhere: this certainly conforms with long range fluctuations and emergence of flux tubes carrying charged particles as dark matter to the environment. Unfortunately, recent day physicist regards Tesla's demonstrations as a mere entertainment and does not bother to ponder whether Maxwell's theory really explains what happens. It is tragic that the greatest intellectual achievements stop thinking for centuries. $h_{gr} = h_{eff}$ hypothesis allows even to estimate the length scales range in which these phenomena should appear.

   Ball lightning (`http://tinyurl.com/5jxd7k`) is also a good candidate for an analogous phenomenon and has been admitted to be a real phenomenon after sixties even by skeptics.

   C. Seward has discovered that di-electric breakdowns generate rather stable torus-like magnetic flux tubes around the breakdown current [H1] (`http://tinyurl.com/ybdrpqju`), which he calls ESTSs (Electron Spiral Toroid Spheromak) and proposed that ball lightnings might correspond to rotating ESTSs.

   In TGD framework the stability might be understood if the toroid corresponds to a magnetic flux tube carrying monopole flux. This would allow to understand stability of the configuration and of ball lightning. Monopole flux tubes could also provide a solution to the plasma confinement problem plaguing hot fusion. Also ordinary lightnings involve poorly understood aspect such as gamma and X-ray bursts and high energy electrons. The common mystery is how the dissipation in atmosphere could allow this phenomena. A possible explanation would be in terms of dark flux tubes generated near criticality to the generation of lightning.

3. So called free energy systems [H4] (for TGD inspired view see the book [K46] include many phenomena claimed to involve a liberation of surplus energy. To my opinion, it is quite possible that over-unity energy production is a transient phenomenon and the dreams about final solution of energy problems will not be fulfilled. What makes these phenomena so interesting to me is that they might involve new physics predicted or at least allowed by TGD.

   The splitting of water represents besides magnetic motors (to be discussed below) a key example of free energy phenomena. In the splitting of water to oxygen and hydrogen the formation of Brown's gas [H4] (Wikipedia article about Brown's gas `http://tinyurl.com/5tyl92` provides an amusing example full of "fringe science"s about how skeptic writes about something inducing cognitive dissonance in skeptic's mind) with strange properties was reported long time ago. For instance, Brown gas is reported to melt metals whose melting temperature is thousands of degrees although the Brown's gas itself has temperature of order 100 degrees Celsius.

   I have proposed an interpretation as large h_{eff} phase containing dark proton sequences at magnetic flux tubes and responsible for the liberation of energy as this phase transforms to ordinary one. Brown's gas could be essentially the fourth phase of water containing exclusion zones (EZs) discovered by Pollack [L4]. The TGD inspired model for them [L4] involves magnetic flux tubes at which part of protons in EZ is transferred and forms dark proton sequences- essentially dark protons. There a many ways to generate Brown's gas: for instance, cavitation due to the mechanical agitation and application of electric fields could do it. The expanding and compressing bubble created by acoustic wave in sono-luminescence

and reported to have a very high temperature and maybe even allowing nuclear fusion, could be also EZ.

4. Water memory [I5, I6, I1] is one of the curse words of skeptic and related to scientific attempts to understand the claimed effects of homeopathy, which defines even stronger curse word in the vocabulary of skeptic - of equal strength as "remote mental interaction". The simple idea that the mere presence of original molecules could be replaced by electromagnetic representation of relevant properties of the molecule is utterly impossible for a skeptic to grasp - despite that also skeptic lives in information society. I have developed a model for water memory explaining also claimed homeopathic effects [K23] and this process has been extremely useful for the development of the model of living matter. Same mechanisms that apply to the model of living matter based on the notion of magnetic body, apply also to water memory and remote mental interactions.

   The key idea is that low energy frequency spectrum provides a representation for the bio-active molecules. The spectrum could be identified as cyclotron frequency spectrum associated with the magnetic bodies of EZs and allow them to mimic the bio-active molecule as far as the effects on living matter are considered. The mechanical agitation of the homeopathic remedy could generate EZs just as it generates cavitation. The model for dark proton sequences yields counterparts of DNA, RNA, amino-acids and even tRNA and genetic code based primitive life would be realized at fundamental particle level with biological realization serving as a higher level representation.

The above sections only list examples about systems where dark matter in TGD sense could appear. A lot of details remain to be understood. The basic question whether some of these systems are permanently near critical state or only in phase transitions between different phases.

4.5 Proposed Mechanisms For Generating Large h_{eff} Phase

I have proposed several mechanisms, which might generate large h_{eff} phase, and an interesting question is whether these mechanisms generate criticality.

1. Generation of strong electric fields near criticality for the di-electric breakdown is consistent with criticality and living matter would provide a key example in this respect. Teslas's strange findings support the view about presence of dark matter phases.

2. The findings of Cyril Smith [I3] suggesting a pairing between low and high em frequencies such that low frequency irradiation of bio-matter creates regions to which one can assign high frequency and corresponding wavelength as a size scale. TGD explanation would be that the ratio f_h/f_l of high and low frequencies equals to the $h_{eff}/h = n$, and there is a criticality in the sense that for integer values of this frequency ratio a phase transition transforming dark low energy photons to high frequency of same energy or vice versa can take place. The reverse transition might be interpreted as an analog of Bose-Einstein condensation for low frequency photons (recall the n-fold covering property). The criticality would thus be associated with the formation of the analog of Bose-Einstein condensate.

3. I have proposed that rotating systems could in certain circumstances make a transition to a critical state in which large h_{eff} phase is generated.

   (a) First motivation comes from a model for the findings reported by Russian experimentalists Roschin and Godin [H5] who studied a rotating magnetic system probably inspired by the work of british inventor Searl. The experimenters claim several unexpected effects near criticality for mechanical breakdown of the system. For instance, cylindrical magnetic walls of thickness of few centimeters with distance of order.5 meters are formed. The system starts to accelerate spontaneously. Cooling of the nearby environment is reported. Also visible light probably due to di-electric breakdown - another critical phenomenon - are reported.

   One of the proposed TGD inspired explanations [K6] suggests that there is energy and angular momentum transfer from the magnetic walls which could contain dark

matter. Dark photons at cyclotron frequencies but possessing energies of visible photons could make the energy transfer very effective. One possibility is the change of direction for spontaneous dark magnetization emitting large amount of energy. Also collective cyclotron transitions reducing the angular momentum of Bose-Einstein condensate like state can be considered.

(b) Second motivation comes from the magnetic motor of Turkish inventor Yildiz [H3, H6], which run for hours in a public demonstration. I have developed a model of magnetic motor, which might contain the essential elements of the motor of Yildiz.

The key idea is that radial permanent magnets generate magnetic monopole flux tubes emanating radially through the stator and rotor returning back along z-axis. Monopole character implies that no current to preserve the magnetic field. This I think is essential.

If the rotor consist of magnets tangential to a circle, a constant torque is generated. Angular momentum and energy conservation of course requires a feed of energy and angular momentum. If dark matter phase is generated, it could come from some magnetic body containing charged particles with spontaneous magnetization and carrying both spin and energy. Also angular momentum of cyclotron Bose-Einstein condensate can be considered. One possibility is that the dark matter associated with Earth estimated later to be a fraction of about $.2 \times 10 \times -4$ of Earth's mass is the provider of angular momentum and energy. The system is certainly critical in the sense that it is near the mechanical breakdown and in some demonstrations the breakdown has also occurred. This of course raises the possibility that the energy feed comes from mechanical tensions.

(c) Third motivation comes from a model of a rotating system to which constant torque is applied. This situation can be described in terms of potential function $V = \tau\phi$ and modelled using Schrödinger equation [K25]. Since V is not periodic function of ϕ, the solution cannot be periodic if τ lasts forever. It is however possible to have a situation in which the duration T of τ is finite. In this case one can consider the possibility that the phase space which is in the simplest situation circle is replaced with its n-fold covering and solutions are periodic with period $n \times 2\pi$ during the period T and before it energy eigenstates for a free system. The average energy for the final state would be differ from that for the initial state and the difference would be the energy fed to the system equal to $\Delta E = \tau\Delta\phi$ classically. During energy feed the systems wave functions have $1/n$-fractional angular momenta unless one assumes $h_{eff} = n \times h$ phase.

What is intriguing that also stationary solutions are obtained: the equation reduces to that for Airy functions in this case. These solutions do not however satisfy periodicity condition for any finite n. Solutions located in a finite covering of circle cannot be energy eigenstates. Could the constancy of energy mean that no dissipation takes place and no energy is feed to the system.

This description brings in mind the general view about large h_{eff} phases as being associated with the breaking of conformal invariance. n could characterize the number of sheets of the covering of S^2. What does criticality correspond to now? Why should angular momentum and energy feed require or imply criticality? There is also a criticality associated with the change of n as the minimum number of periods that τ lasts. If this is the correct identification, the value of n would increase after every turn in positive energy ontology. In ZEO it would be pre-determined and determined by the duration of τ.

The motivation for the model comes from the ATPase molecule (`http://tinyurl.com/y9jxsvr5`), which is a basic tool in energy metabolism. ATPase can be regarded as a molecular motor taking its energy from the change of the energy of protons as they flow through the cell membrane. Three ADPs are transformed to ATP during single turn by giving them phosphate molecule. What could make the system critical? The system in question is not neuronal membrane but there is tendency to consider the possibility that also the mitochondrial membrane potential is near to breakdown value and the flow of protons through it is the counterpart for nerve pulse.

4. TGD inspired model [L3] for the recent findings about microtubules by the group of the group of Bandyonopadhyay. [J1, J3] is based on the assumption that the oscillatory em perturbation

of the system induces generation of A type microtubules not present in Nature by a phase transition from B type microtubules. This phenomenon would take for a critical frequency and $f_h/f_l = n$ condition is suggestive. The proposal is that large h_{eff} phase is generated and gives rise to long range correlations at the level of microtubule so that 13-tubulin units combine to form longer units and the broken helical symmetry becomes un-broken symmetry. Quite recently also an observation of short lasting (nanoseconds) super-conductivity at room temperature (`http://tinyurl.com/prvjp6y`) induced by irradiation of high temperature super conductor with infrared light. The mechanism could be similar and involve $f_h/f_l = n$ condition.

5 Applications to Condensed Matter

5.1 Mysterious Action At Distance Between Liquid Containers

This section as also the consideration of the idea that criticality could involve a phase transition transforming ordinary matter to dark matter was inspired by a link sent by Ulla. The link was to a popular article (`http://tinyurl.com/yaaqnebp`) telling about mysterious looking action at a distance between liquid containers.

For several years it has been that superfluid helium in reservoirs next to each other with distance of few micrometers acts collectively, even when the channels connecting them are so thin and long that substantial flow of matter between them is not possible. The article mentions a theoretical model [B1] developed by a team of scientists include those from the Instute of Physical Chemistry of the Polish Academy of Sciences in Warzaw (IPCPACW). According to the article the model reveals that the phenomenon is much more general than previously thought and could take place also systems which are usually regarded as classical (what this actually means in quantum world is not quite clear!). The reading of the abstract of the article (`http://tinyurl.com/y7pmbw2k`) shows that only Monte Carlo studies are done so that "predicts" is more appropriate than "reveals".

According to the article, the first report about "action at a distance" was between superfluid reservoirs was published in 2010 in Nature Physics [D20] (`http://tinyurl.com/y7pfc9a9`). The team from the University of Buffalo and the State University of New York created an array of tens of millions of cubical reservoirs containing liquid healiium on a silicon plate. The centres of reservoirs had distance of 6 μ and the reservoirs had edge length of 2 μm so that the width of the horizontal gap between reservours was 4 μm. The reservoirs were covered with another silicon plate with a very thin gap above the reservoirs allowing to fill them with liquid helium. The thickness of this vertical gap was $d = 32$ nm - in TGD language this is $d = 3.2L(151)$, where the p-adic length scale $L(151) = 10$ nm defines the thickness of cell membrane The gap was so thin that it did not allow a significant flow of liquid helium between the different reservoirs.

Remark: To be precise, $L(151)$ should be called the Compton length of electron if it would correspond to Gaussian Mersenne $MG, k = 151 = (1+i)^k - 1$ and is $L_e(151) = \sqrt{5} \times L(151)$, where $L(151)$ would be the genuine p-adic length scale. For brevity I often call L_e just p-adic length scale and drop the subscript "e".

The expectation was that different reservoirs would behave like independent systems without interactions. In particular, the specific heat of the whole system would be sum over the specific heats of individual systems, which were identical. This was not the case. An excess of specific heat was observed in the system. The super-fluid helium was acting as a physical whole.

The natural explanation would be in terms of the superfluid character of the systems. Still the absence of the direct contact - say thin "threads" connecting the reservoirs - makes one to wonder whether the situation can be understood in the framework of conventional quantum physics.

In co-operation with Prof. Douglas Abraham from Oxford University, Dr. Maciolek from (IPCPACW) has developed a theory to exlain the observations [B1] (`http://tinyurl.com/y7pmbw2k`). The new theory predicts that the effect of "action at a distance" does not require quantum physics and can also occur in classical one-component fluids, as well as its mixtures. The article says that this theory is confirmed by computer simulations carried out by Oleg Vasilyev from the Max-Planck Insitute für Intelligente Systeme. I would be here a little bit skeptical: experiments conform, computer simulations only allow to calculate!

The theory makes certain predictions.

1. Super-fluidity is not a necessary condition. The phenomenon can occur if the system is near criticality and thus involves at least two different phases of matter. Therefore low temperatures a not necessary. For instance, water and lutidine - a model mixture of water and oil - mix only in certain temperature range and "action at a distance" appears only in this range. On basis of the popular article it remains clear whether this is a prediction or an experimental fact.

2. The dimensions of the reservoins and the connecting channels are also important. The phenomenon ceas the distances are significantly larger than the size of human cells.

Some comments from TGD based view about criticality already summarize are in order.

1. The notion of "classical" can be misleading. One can model physical phenomena classically - thermodynamical phase transitions are basic example of this but the microscopic - and also non-microscopic physics of long range correlations - can be actually quantal. Basically all physics is quantal and during last years people have begun to learn that even macroscopic physical can behave non-classically. In TGD framework however quantum physics as classical space-time correlates and this brings a new element.

2. The key question is what makes the superfluids closed in the reservoirs to behave like single quantum coherent system in the first experiment. TGD based view about space-time correlates of criticality and long range correlations associated with suggests that magnetic flux tubes or sheets connecting the superfluid reservoirs are essential. Even more, these flux quanta - possible carrying monople fluxes - would be universal space-time correlates of any critical phenomenon. In separate section I will discuss a model for the fountain effect exhibited by ^4He based on the notion of flux quantum carrying the genuine super fluid (normal and super-fluid component are involved) having non-standard value of Planck constant, which is rather large so that the gravitational Compton length is macroscopic length and the effects of gravitation the wave function are very small and the super-fluid apparently defies gravitational force.

3. Second question is why cell length scale of few microns would serve as a prerequisite for the phenomenon. The length scale range 10 nm-2.5 μm involves as many as four p-adic length scales labelled by Gaussian Mersennes ($k = 151, 157, 163, 167$ and corresponds to length scale range between thickness of cell membrane and cell nucleus size. TGD suggests strongly dark variants of weak with $h_{eff} = n \times h$ and also strong physics with corresponding gauge bosons being effective as massless particles below these length scales. The exchange of these massless bosons would generate long range correlations at criticality. Also p-adic variants of these physics with mass scales of weak bosons reduced to a range varying in 1-100 eV range would be involved if TGD vision is correct. Hence criticality would involve quantum physics and even dark matter!

4. Phase separation - be it separation of particles in mixture or phases of say water - is very relevant of criticality. How this happens. The TGD answer already considered relies on the notion of hierarchy of Planck constants $h_{eff} = n \times h$ and universality of cyclotron frequencies associated with magnetic flux tubes and due to the identification $\hbar_{eff} = \hbar_{gr} = GMm/v_0$ already discussed. The large mass M is the mass of the dark fraction of the Earth's mass. This implies that Planck constant characterizes particle and also that the gravitational Compton length is same for all particles and the energy spectrum of cyclotron radiation is universal and in the range of visible and UV energies associated with bio-photons.

   All these predictions conform nicely with the universality of criticality. The prediction is that bio-photons would accompany any Earthly critical system. What of course raises the eyebrows of skeptics is the proposed dependence of critical phenomena on the dark gravitational mass of the planet or system which the system is part of.

5.2 The Behavior Of Superfluids In Gravitational Field

Superfluids apparently defy gravitational force as so called fountain effect (`http://tinyurl.com/kx3t52r`) demonstrates. In the following TGD inspire model based on the hypothesis that the

genuine superfluid part of superfluid at least near criticality corresponds to large h_{eff} phase is considered.

5.2.1 Fountain effect

In an arrangement involving a vessel of superfluid inside another one such that the levels of superfluids are different in the two vessels, the superfluid flows spontaneously along the walls of the vessels as a superfluid film. The flow is from the vessel in which the level of superfluid is higher until the heights are equal or *all* fluid has left the other container. For illustrations see the pictures of the article (see `http://tinyurl.com/h66hydb`) [D21] "Why does superfluid helium leak out of an open container?".

What is strange that all the fluid flows from the vessel to another one it the height of vessel is high enough. According to the prevailing wisdom super-fluid actually consists of ordinary fluid and genuine superfluid. The fluid flows from the vessel as a genuine superfluid so that the process must involve a phase transition transforming the ordinary fluid component present in the fluid to superfluid keeping superfluid fraction constant. A further strange feature is that the superfluid flows as a film covering the inner (and also outer) surface of entire container so that return flow is not possible. This suggests interpretation as a macroscopic quantum phenomenon

According to the article of Golovko the existing wisdom about flow is that it corresponds to wetting. This would however predict that the phenomenon takes place also above the critical point (λ point) for the ordinary fluid. This is not the case. Secondly, the force responsible for the sucking the superfluid from the container would act only at the boundary of the film. As the film covers both the interior and exterior walls of the container the boundary vanishes, and therefore also the force so that the flow of the superfluid to another container should stop. The amount of the superfluid leaving the container should be small and equal to the amount of super-fluid in the film: this is not the case. Hence the conventional explanation does not seem to work.

5.2.2 TGD inspired model for the fountain effect

What could be the TGD explanation for fountain effect?

Macroscopic quantum coherence in the scale of the film is suggestive and hierarchy of Planck constants $h_{eff} = n \times h$ and magnetic flux quanta suggest themselves. Whether this notion is relevant also for the description of the super-fluid itself is not of course obvious and one might argue that standard description is enough. Just for fun, we can however for a moment assume that the super-fluid fraction could correspond to a dark phase of 4^He located at flux quanta. The natural candidates for the flux quanta is a flux sheet connecting the vessel to the external world or smaller vessel and larger vessel to each other. The flux sheet would accompany the film covering the inside and outside walls. The fact that the flow seems to defy gravitational force suggests that macroscopic quantum coherence is involved in these degrees of freedom and that one should describe the situation in terms of wave function for super-fluid particles in the gravitational potential of Earth. For ordinary value of Planck constant one cannot of course expect macroscopic quantum coherence since coherence length is not expected to be much larger than Compton length. TGD predicts that h_{eff} characterizes Kähler magnetic flux tubes at which the dark Bose-Einstein condensate resides. There can consider several identifications of h_{eff} corresponding to gravitational interaction, electromagnetism, or long range Z^0 interaction possible in TGD and originally associated with super-fluidity interpreted as Z^0 superconductivity.

3. (a) For gravitational interaction, the identification is $h_{eff} = h_{gr}$, where h_{gr} is what I call gravitational Planck constant of Nottale [**?**]

$$\hbar_{gr} = \frac{GMm}{v_0} = \frac{r_S m}{2\beta_0} \quad , \quad \beta_0 = \frac{v_0}{c} \tag{5.1}$$

In the expression of h_{gr} M is the "large" mass - naturally Earth's mass M_E. m would be the mass of ^4He atom. $r_S = 2GM/c$ denotes Schwartschild radius of Earth, which

from $M_E = 3 \times 10^{-6} M_{Sun}$ and from $r_S(Sun) = 3$ km is 4.5 mm. v_0 could be some characteristic velocity for Earth-super fluid system and the rotation velocity $v_0 = 465.1$ m/s of Earth is the first guess. However, the model for cyclotron frequencies of dark ions favor rather large value of v_0, say $v_0/c = 1/2$.

The gravitational Compton length $\lambda_{gr} = h_{gr}/m$ does not depend on the mass of the particle and equals to $\lambda_{gr} = GM/v_0 \simeq 645$ meters for $v_0 = 465.1$ m/s. The scale of the superfluid system would be much smaller than the minimum coherence length, which does not look plausible.

(b) The generalization of Nottale's formula to the electromagnetic case would be $\hbar_{em} = Q_{em} e^2/v_0 > \hbar$. Q_{em} should refer to the em charge of super-fluid but this is essentially zero so that this option is not feasible.

(c) According to the standard model, the nuclear Z^0 charges are indeed non-vanishing in the standard model, where Z^0 quanta are massive. In TGD framework, one can however argue that they are actually screened above weak boson Compton length. For $\hbar_{eff} = \hbar_Z$ the intermediate boson Compton length could be scaled up by the factor $\hbar_Z/\hbar$ so that Z^0 quanta would be effectively massless below this screening scale.

The generalization of the Nottale's formula would read as $\hbar_Z = Q_Z g_Z^2/v_0$, where ZQ_Z refers to the total Z^0 charge of the super-fluid phase. Cell scale would require $h_Z/h \sim 10^{11}$. Screening scale is atomic for $h_Z/h \sim 10^7$: this value turns out to be too large. A value of order 2^8 is required. If the screening of nuclear charges in the scale of ^4He nuclei, one would have $h_Z/h \sim 100$. This value of h_Z/h is however not consistent with the Nottale's hypothesis and with the idea about scaled up weak boson Compton length.

A possible way to solve this problem is to assume that weak bosons can also appear at electroweak p-adic scales which differ from intermediate boson length scale [K26] and have scaled down masses. If this scale corresponds to the atomic p-adic length scale $L(k = 137)$ as the size scale of Cooper pairs suggests, then $h_Z \simeq 2^8$ would correspond to the p-adic length scale $L(153)$ ($L(151) \simeq 10$ nm corresponds to cell membrane thickness).

A simple model for the situation discussed would rely on Schrödinger equation at the flux quantum which is locally a thin hollow cylinder turning around at the top of the wall of the container.

(a) One obtains 1-dimensional Schrödinger equation

$$(-\frac{\hbar_{eff}^2 \partial_z^2}{2m} + m g_{eff} z)\Psi = E\Psi \quad , \quad h_{eff} = n h_0 = \frac{nh}{6} \quad . \tag{5.2}$$

It is easy to see that the energy spectrum is invariant under the scaling $h \to h_{eff} = xh$ and $z \to z/x$. One has $\Psi_{xh, g_{eff} = g/x}(z) = \Psi_{h,g}(z/x)$ so that simple scaling of the argument z in question. The energy of the solution is same. If the ordinary solution has size scale L, the scaled up solution has size scale xL.

The height for a trajectory in gravitational field of Earth is scaled up for a given initial vertical velocity v_i is scaled as $h \to xh$ so quantum behavior corresponds to the classical behavior and de-localization scale is scaled up. Could this happen at various layers of magnetic body for dark particles so that they would be naturally at much higher heights. Cell scale would be scaled to Earth size scale of even larger sizes for the values of $\hbar_{eff}/h = n$ involved.

For classical solution with initial initial vertical velocity $v_i = 1$ m/s the height of the upwards trajectory is $h = v_i^2/2g$ 5 cm. Quantum classical correspondence would be given by $E = mv_i^2/2$ and this allows to look the delocalization scale of a solution.

(b) One can introduce the dimensionless variable u (note that one has $g_{eff}/g = 1/x$, $x = h/h_{eff}$) as

$$u = \frac{z - \frac{E}{mg_{eff}}}{z_0} \quad , \qquad z_0 = \left[\frac{2m^2 g_{eff}}{\hbar_{eff}^2}\right]^{-1/3} = \frac{h_{eff}}{h}(\frac{m}{m_p})^{2/3} \times (\frac{g}{L_p^2})^{-1/3} \simeq \frac{h_{eff}}{h} \times (\frac{m}{m_p})^{2/3} \times 2.4$$

$$L_p = \frac{\hbar c}{m_p} = \simeq 2.1 \times 10^{-16} \text{ m} \quad ,$$

(5.3)

Here m_p denotes proton mass and L_p proton Compton length. z_0 scales as $\hbar_{eff}$ as one might expect. z_0 characterizes roughly the scale of the s lution. From the scale of the fountain effect about 1 meter, one can conclude that one should have $h_{eff}/h \sim 2^8$.

This allows to cast the equation to the standard form of the equation for Airy functions encountered in WKB approximation

$$-\frac{d^2\Psi}{du^2} + u\Psi = 0 \quad . \tag{5.4}$$

Remark: Note that the classical solution depends on m. In central force problem with $1/r$ and $h_{eff} = GMm/v_0$ the binding energy spectrum $E = E_0/n^2$ has scale $E_0 = v_0^2 m$ and is universal.

(c) The interesting solutions correspond to Airy functions $Ai(u)$ which approach rapidly zero for the values of $u > 1$ and oscillate for negative values of u. These functions $Ai(u + u_1)$ are orthogonal for different values of u_1. The values of u_1 correspond to different initial kinetic energies for the motion in vertical direction. In the recent situation these energies correspond to the initial vertical velocities of the super-fluid in the film. $u = u_0 = 1$ defines a convenient estimate for the value of z coordinate above which wave function approaches rapidly to zero.

For classical solution with initial initial vertical velocity $v_i = 1$ m/s the height of the upwards trajectory is $h = v_i^2/2g$ 5 cm. Quantum classical correspondence would be given by $E = mv_i^2/2 = E$ and this allows to look the delocalization scale of a solution.

The Airy function $Ai(u)$ approaches rapidly to zero (see the graph of `https://en.wikipedia.org/wiki/Airy_function`) and one can say that above $u_0 = 3$ the function vanishes. Already at $u_0 = 1$ wave function is rather small as compared with its value at $u = 0$. This condition translates to a condition for z as

$$z_0 = z_{cl} + u_0 z_0 \quad , \quad z_{cl} = \frac{E}{mg_{eff}} \quad , \quad z_0 = \frac{h_{eff}}{h}\left[\frac{\hbar^2}{2m^2 g}\right]^{1/3} \quad . \tag{5.5}$$

The condition is consistent with the classical picture and the classical height z_{cl} scales like h_{eff}/h. The parameter $u_0 z_0$ defines the de-localization scale consistent with the expectations. Below z_{cl} the wave function oscillates which intuitively corresponds to the sum of waves in upwards and downwards directions.

What can one conclude about the value of $x = h_{eff}/h_0$ in the case of super-fluidity?

i. Using the previous formula, the condition that z_0 is of order 1 meter fixes its value to $h_{eff}/h_0 \sim 2^8$. Could super-fluidity correspond to the value of $h_{eff} = h_{em} > h$ assignable to electromagnetic flux tubes? The generalization $h_{em} = Ze^2/v_0$ of the Nottale's formula would require that the super fluid phase has a large total em charge Z. The Cooper pairs are however neutral. This leaves under consideration only the old idea that super-fluidity corresponds to Z^0 super-conductivity inspired by the idea that TGD predicts long range Z^0 fields and by the fact that nuclei carry indeed carry non-vanishing Z^0 charge mostly due to neurons.

ii. Both $\hbar_{eff}(gr)/\hbar \simeq 2^{24}$ and $\hbar_{gr} = GMm/v_0$ given by Nottale's hypothesis give quite too large value of z_0.

The gravitational Compton length λ_{gr} is given by $\lambda_{gr} = GM_e/v_0 = r_S/2v_0$ and - in accordance with the Equivalence Principle - does not depend on m. The

Schwartschild radius of Earth is $r_S = .9$ cm. One could argue that λ_{gr} is a reasonable lower bound for z_0 if h_{gr} appears in the gravitational Schrödinger equation. For $v_0/c = 2^{-11}$ required by the Bohr orbit model for the 4 inner planets, this would give $\lambda_{gr} = 9$ m. The energy scale of dark cyclotron states comes out correctly if one has $v_0/c = 1/2$ giving the lower bound $z_0 \geq r_S = .9$ cm.

However, the proportionality of z_0 to h_{eff}/h implies that the z_0 is scaled by a factor of order $2GM_Em_p/v_0 \sim 10^{14}$ from its value $z_0 = .2$ mm and would be gigantic. It seems that this option indeed fails.

iii. Could the fountain effect be due to the reduction of g in principle possible if G is prediction and CP_2 length replaces Planck length as fundamental scale? If one assumes $h_{eff} = h$ and scaled down value of g corresponding to $G_{eff} = R^2/\hbar_{gr}$ such that $\hbar_{gr}$ is scaled from its normal value: $\hbar_{gr} \to y\hbar_{gr}$, $G_{eff} \to G_{eff}/y$. This would give the scaling of $z_0 \propto g^{-1/3}$ as $z_0 \to y^{1/3}z_0$ giving $z_0 \simeq .2$ mm should be scaled up to about 1 mm which would give $y \sim 10^9$. This would mean a huge breaking of Equivalence Principle.

5.2.3 Superfluids dissipate!

People in Aalto University - located in Finland by the way - are doing excellent work: there is full reason to be proud! I learned from the most recent experimental discovery by people working in Aalto University from Karl Stonjek. The title of the popular article (see `http://tinyurl.com/yagsttw7`) is "*Friction found where there should be none—in superfluids near absolute zero*".

In rotating superfluid one has vortices and they should not dissipate. The researchers of Aalto University however observed dissipation: the finding by J Mäkinen *et al* is published in in Phys Rev B [D19] (see `http://tinyurl.com/y7dtsdys`). Dissipation means that they lose energy to environment. How could one explain this?

What comes in mind for an inhabitant of TGD Universe, is the hierarchy of Planck constants $h_{eff} = n \times h$ labelling a hierarchy of dark matters as phases of ordinary matter. The reduction of Planck constant h_{eff} liberates energy in a phase transition like manner giving rise to dissipation. This kind of burst like liberation of energy is mentioned in the popular article "glitches" in neutron stars). I have already earlier proposed an explanation of fountain effect of superfluidity in which superfluid flow seems to defy gravity. The explanation is in terms of large value of h_{eff} implying delocalization of superfluid particles in long length scale [**?**] (see `http://tinyurl.com/y8xhvwt2`).

Remark: Quite generally, binding energies are reduced as function of $h_{eff}/h = n$. One has $1/n^2$ proportionality for atomic binding energies so that atomic energies defined as rest energy minus binding energy indeed increase with n. Interestingly, dimension 3 of space is unique in this respect. Harmonic oscillator energy and cyclotron energies are in turn proportional to n. The value of n for molecular valence bonds depends on n and the binding energies of valence bonds decrease as the valence of the atom with larger valence increases. One can say that the valence bonds involving atom at the right end of the row of the periodic table carry metabolic energy. This is indeed the case as one finds by looking the chemistry of nutrient molecules.

The burst of energy would correspond to a reduction of n at the flux tubes associated with the superfluid. Could the vortices decompose to smaller vortices with a smaller radius, maybe proportional to n? I have proposed similar mechanism of dissipation in ordinary fluids for more than two decades ago. Could also ordinary fluids involve hierarchy of Planck constants and could they dissipate in the same manner?

In biology liberation of metabolic energy - say in motor action - would take place in this kind of "glitches". It would reduce h_{eff} resources and thus the ability to generate negentropy: this leads to smaller negentropy resources and one gets tired and thinking becomes fuzzy.

5.2.4 An improvement of the flux tube picture

The above arguments related to fountain effect cry for a more precise formulation of the rather loose ideas about how gravitational interaction is mediated by flux tubes.

It has been assumed that $\hbar_{gr} = GMm/v_0$ characterizes the flux tubes connecting mass M - say solar mass - to a smaller mass m. This assumption cannot be correct as such.

i. The assumption treats the two masses asymmetrically.

ii. A huge number of flux tubes is needed since every particle pair $M-m$ would involve a flux tube. It would be also difficult to understand the fact that one can think the total gravitational interaction in Newtonian framework as sum over interactions with the composite particles of M. In principle M can be decomposed into parts in many ways - elementary particles and their composites and larger structures formed from them: there must be some subtle difference between these different compositions - all need not be possible - not seen in Newtonian and GRT space-time but maybe having representation in many-sheeted space-time and involving h_{gr}.

iii. Flux tube picture in the original form seems to lead to problems with the basic properties of the gravitational interaction: namely superposition of gravitational fields and absence or at least smallness of screening by masses between M and m. One should assume that the ends of the flux tubes associated with the pair pair $M - m$ move as m moves with respect to M. This looks too complex.

Linear superposition and absence of screening can be understood in the picture in which particles form topological sum contacts with the flux tubes mediating gravitational interaction. This picture is used to deduce QFT-GRT limit of TGD. Note that also other space-time sheets can mediate the interaction and pairs of MEs and flux tubes emanating from M but not ending to m are one possible option. In the following I however talk about flux tubes.

These problems find a solution if h_{gr} characterizes the *magnetic body* (MB) of a particle with mass m topologically condensed to a flux tube carrying total flux M. m can also correspond to a mass larger than elementary particle mass. This makes the situation completely symmetric with respect to M and m. The essential point is that the interaction takes place via touching of MB of m with flux tubes from M.

i. In accordance with the fractality of the many-sheeted space-time, the elementary particle fluxes from a larger mass M can combine to a sum of fluxes corresponding to masses $M_i < M$ with $\sum M_i = M$ at larger flux tubes with $\hbar_{gr} = GMM_i/v_{0,i} \geq \hbar$. This can take place in many ways, and in many-sheeted space-time gives rise to different physical situations.

Due to the large value of h_{gr} it is possible to have macroscopic quantum phases at these sheets with a universal gravitational Compton length $L_{gr} = GM_im/v_0$. Here m can be also a mass larger than elementary particle mass. In fact, the convergence of perturbation theory indeed makes the macroscopic quantum phases possible. This picture holds true also for the other interactions. Clearly, many-sheeted space-time brings in something new, and there are excellent reasons to believe that this new relates to the emergence of complexity - say via many-sheeted tensor networks [L14].

ii. This picture implies that fountain effect is a kind of antigravity effect for dark matter - maybe even for non-microscopic masses m - since the larger size of MB implies larger average distance from the source of the gravitational flux. This might have technological applications some day.

This picture is a considerable improvement but there are still problems to ponder. In particular, one should understand why the integer $n = h_{eff}/h = h_{gr}/h$ interpreted as a number of sheets of the singular covering space of MB of m emerges topologically. The large value of h_{gr} implies a huge number of sheets.

Could the flux sheet covering associated with M_i code the value of M_i using as unit Planck mass as the number of sheets of this covering? One would have $N = M/M_{Pl}$ sheeted structure with each sheet carrying Planckian flux. The fluxes experienced by the MB of m in turn would consist of sheets carrying fusion $n_m = M_{Pl}v_0/m$ Planckian fluxes so that the total number of sheets would be reduced to $n = N/m = GMm/v_0$ sheets.

Why this kind of fusion of Planck fluxes to larger fluxes should happen? Could quantum information theory provide clues here? And why v_0 is involved?

5.2.5 What about Sun?

Just for interest one can also look what one obtains in the case of Sun: this also leads to a guess for a general formula for the parameter v_0.

i. The replacement of Earth-particle system with particle-Sun system requires scaling r_S by a factor $10^6/3$, the scaling of R_E by factor about 110, and scaling of v_0/c by factor 4.3 if v_0 is identified as solar rotation velocity. The resulting value of z_0 is 1.7×10^{10} m whereas the distance of Earth from Sun is $R = 1.5 \times 10^{11}$ m, roughly 10 times larger than z_0.

ii. On the other hand, of one uses the value $v_0/c \simeq 2^{-11}$ needed in the model of inner planetary orbits as Bohr orbits, one obtains $z_0 = 7.3 \times 10^8$ m to be compared with the value of solar radius $R_S = 6.96 \times 10^8$ meters. For this value of v_0 the gravitational Compton length is $\lambda_{gr} = 6 \times 10^6$ meters, which happens to be rather near to the Earth's radius.

iii. The challenge is to predict the value of the parameter v_0. The above observation suggests that one could pose the consistency consistency condition $R = z_0$ to fix the value of v_0. This would give the formula

$$\beta_0 = (\frac{r_s}{4\pi R})^{1/2} \quad .$$

This scales up β_0 from 1.6×10^{-6} to 2.3×10^{-6} by a factor $1.41 \simeq \sqrt{2}$. For Sun one obtains $\beta_0 = 5.85 \times 10^{-4}$ consistent with the value required by Bohr quantization.

5.2.6 Evidence for macroscopic quantum coherence of fluid flow at criticality

Evidence for the hierarchy of Planck constants implying macroscopic quantum coherence in quantum critical systems is rapidly accumulating. Also people having the courage to refer to TGD in their articles are gradually emerging. A series of fluid dynamics experiments (`http://tinyurl.com/jpf5f5j`) providing this kind of evidence is performed by Yves Couder and Emmanuel Fort (see for instance [D3]). Mathematician John W. M. Bush has commented [D17] (`http://tinyurl.com/jskythl`) these findings in the Proceedings of National Academy of Sciences and the article provides references to a series of papers by Couder and collaborators.

The system studied consist of a tray containing water at a surface, which is oscillating. The intensity of vibration is just below the critical value inducing so called Faraday waves (`http://tinyurl.com/hwuloet`) at the surface of water. Although the water surface is calm, water droplet begins to bounce and generates waves propagating along the water surface - "walkers". Walkers behave like classical particles at Bohr orbits. As they pass through a pair of slits they behave they choose random slit but several experiments produce interference pattern. Walkers exhibit an effect analogous to quantum tunneling and even the analogs of quantum mechanical bound states of walkers realized as circular orbits emerge as the water tray rotates!

The proposed interpretation of the findings is in terms of Bohm theory (`http://tinyurl.com/homasgz`). Personally I find it very difficult to believe in this since Bohm's theory has profound mathematical difficulties. Bohm's theory was inspired by Einstein's

belief on classical determinism and the idea that quantum non-determinism is not actual but reduces to the presence of hidden variables. Unfortunately, this idea led to no progress.

TGD is analogous to Bohm's theory in that classical theory is exact but quantum theory is now only an exact classical correlate: there is no attempt to eliminate quantum non-determinism. Quantum jumps are between superpositions of entire classical time evolutions rather than their time=constant snapshots: this solves the basic paradox of Copenhagen interpretation. A more refined formulation is in terms of zero energy ontology, which in turn forces to generalize quantum measurement theory to a theory of consciousness.

Macroscopic quantum coherence associated with the behavior of droplets bouncing on the surface of water is suggested by the experiments. For instance, quantum measurement theory seems to apply to the behavior of single droplet as it passes through slit. In TGD the prerequisite for macroscopic quantum coherence would be quantum criticality at which large $h_{eff} = n \times h$ is possible. There indeed is an external oscillation of the tray containing water with an amplitude just below the criticality for the generation of Faraday waves at the surface of water. Quantum classical correspondence states that the quantum behavior should have a classical correlate. The basic structure of classical TGD is that of hydrodynamics in the sense that dynamics reduces to conservation laws plus conditions expressing the vanishing of an infinite number of so called supersymplectic charges - the conditions guarantee strong form of holography and express quantum criticality. The generic solution of classical field equations could reduce to Frobenius integrability conditions guaranteeing that the conserved isometry currents are integrable and thus define global coordinates varying along the flow lines [K43]. The correlate for quantum criticality would be classical criticality and criticalities for various hydrodynamical stabilities would serve as excellent candidates for the situation in which large h_{eff} should become manifest.

One should of course be very cautious. For ordinary Schrödinger equation the system is closed. Now the system is open. This is not a problem if the only function of external vibration is to induce quantum criticality. The experiment brings in mind the old vision of Frölich about external vibrations as induced of what looks like quantum coherence. In TGD framework this coherence would be forced coherence at the level of visible matter but the oscillation itself would correspond to genuine macroscopic quantum coherence and large value of h_{eff} [L9]. A standard example is provided by penduli, which gradually start to oscillate in unisono in presence of weak synchronizing signal. In brain neurons would start to oscillator synchronously by the presence of dark photons with large h_{eff}.

5.3 The mysterious dichloromethane droplet, which refuses to sink in water and begins to spin

I received from Resonance Foundation a link to an interesting article "*Chemists baffled by droplet spiraling to its doom*" (see `http://tinyurl.com/y4f46jh4`) telling about the strange behavior of droplets of dichloromethane (DCM) at the surface of water. DCM is heavier than water and one would expect it to sink down but it doesn't: it floats and starts to spin emitting smaller droplets from its boundary so that it eventually decays compeltely. This is like evaporation process said to resemble the behavior of spiral galaxy.

I could understand why the droplet floats - by creating a film acting as a boat - and Marangoni effect causing the droplet to decay by emitting smaller droplets (being due to the reduction of string tension at droplet water interface causing radial outwards directed tangential force).

But I could not understand how droplet could start to rotate? Where is the opposite angular momentum. Does water below the droplet rotate in opposite direction?

One strategy in TGD framework is to proceed in general manner.

i. Self-organization process is in question and the rotation could have interpretation as generation long length scale motion requiring long range correlations. Also the

build-up of a "boat" as liquid layer coming from droplet allowing the rest of droplet to float instead of sinking to the water would be part of this process.

ii. Energy feed is always involved with all self-organization processes. In TGD Universe one can ask whether self-organizing systems are analogous to living systems (see `http://tinyurl.com/y3xbkokb`). For living systems in TGD Universe the metabolic energy feed is needed to keep the distribution of subsystems with Planck constant $h_{eff} = nh_0$ larger than its standard value and responsible for long range quantum correlations. This because the larger the value of h_{eff} characterizing the phase of ordinary matter is, the larger the energy of the system is, and because h_{eff} tends to decrease spontaneouly. Phase of ordinary mattter with nonstandard value of h_{eff} has interpretation as dark matter.

Quantum scales are typically proportional to h_{eff} and large value means long scale of quantum coherence at the level of magnetic body which serves as a "boss" of ordinary matter in master slave hierarchy. If so, dark matter in TGD Universe would be visible through self-organization processes: quantum coherence in long lengths cales would force self-organization and generation of long range correlations.

iii. This picture would suggestthat also now magnetic body carrying dark matter phases is present. Could the angular momentum opposite to that of the rotating droplet be assigned with the rotating dark matter at magnetic body? I have proposed analogous explanation for the spontaneous accelerration rotation in rottatin magnetic systems reported by Godin and Roschin: (see `http://tinyurl.com/yyzld5ml`) . It should be easy to kill this hypothesis: the alternative standard physics option is that it is in the liquid below the droplet so that it would rotate in opposite direction.

iv. Where does the needed "metabolic" energy feed come from. The decay of the droplet means that its surface tension is reduced. Surface tension measures the surface energy density so that surface energy must be lost. Could part of this energy go to the self-organization as "metabolic" energy for magnetic body and for rotational. Part of energy would go to the radial motion of smaller droplets emanating from the droplet.

v. Surface tension is thought to be due to cohesive forces. In case of water and some other liquids hydrogen bonds would be responsible for them. London forces would be attractive interactions between dipoles of polarizable molecules and would contribute for polar molecules. Surface tension characterizes surface energy density and thus energy could come from this as the droplet decays to smaller ones. But does this make sense?

One can argue that this decay to smaller droplets increases surface area so that the process would not liberate energy but require it. The droplet is believedto float by reducing its density (Arhimedes law). This must increases its volume. Could the emitted droplets have the original original density so that their volume would be smaller and surface area too. Could this reduce the total surface energy in the process? The rest would go to rotation?

In FB Wes Johnson suggested that water droplet could act as a propeller. The droplet indeed looks like a propeller. Probably you mean that propeller property causes lift so that buoynancy would not be needed? This looks like a good idea. There would be two models. Propellor model and buoynancy model.

i. For the buoynancy model the expansion of the droplet could provide the needed buoyancy: the density of the droplet should become smaller than that of water. Droplet would generate a membrane serving as a boat. The droplet would expand and this expansion would store energy, which would be liberated. Where do the energy and angular momentum come from?

ii. Both options lead to the same question. Were do energy angular momentum come? Could the energy and angular momentum come from water or from the flux tubes/sheets of the magnetic body of water as h_{eff} decreases and liberates

energy? Flux tubes in water accompany hydrogen bonds and even long flux tubes could correspond to hydrogen bonds. Magnetic body of water would save the droplet from drowning!

iii. This argument involves only energy. Entropy is also involved. I just wrote a little article about application of minimization of Gibbs energy G to water in TGD sense. One has $\Delta G = \Delta H - T\Delta S \leq 0$, H is enthalpy, the heat used or liberated. It is safest to have $\Delta S > 0$. If flux tubes in water shorten, long range order reduced to that in shorter length scale so that entropy is generated. This liberates also energy if long dark flux tubes behave like hydrogen bonds.

5.4 Does The Physics Of SmB_6 Make The Fundamental Dynamics Of TGD Directly Visible?

The group of Suchitra Sebastian has discovered very unconventional condensed matter system, which seems to be simultaneously both insulator and conductor of electricity but only in presence of magnetic field. Science article is entitled "Unconventional Fermi surface in an insulating state" [L8] (see `http://tinyurl.com/y79qo7lp`). There is also a popular article with title "Paradoxical Crystal Baffles Physicists" in Quanta Magazine summarizing the findings (see `http://tinyurl.com/qhwdmxj`). I learned about the finding first from the blog posting of Lubos Motl (see `http://tinyurl.com/yacm6bj7`).

5.4.1 Observations

The crystal studied at superlow temperatures was Samarium hexaboride - briefly SmB_6. The high resistance implies that electron cannot move more that one atom's width in any direction. Sebastian et al however observed electrons traversing over a distance of millions of atoms- a distance of orde 10^{-4} m, the size of a large neuron. So high mobility is expected only in conductors. SmB_6 is neither metal or insulator or is both of them! The finding is described by Sebastian as a "big schock" and as a "magnificent paradox" by condensed matter theorists Jan Zaanen. Theoreticians have started to make guesses about what might be involved but accorrding to Zaanen there is no even remotely credible hypothesis has appeared yet.

On basis of its electronic structure SmB_6 should be a conductor of electricity and it indeed is at room temperature: the average number conduction electrons per SmB_6 is one half. At low temperatures situation however changes. At low temperatures electrons behave collectivily. In superconductors resistance drops to zero as a consequence. In SmB_6 just the opposite happens. Each Sm nucleus has the average 5.5 electrons bound to it at tight orbits. Below 223 degrees of Celsius the conduction electrons of SmB_6 are thought to "hybridize" around samarium nuclei so that the system becomes an insulator. Various signatures demonstrate that SmB_6 indeed behaves like an insulator.

During last five years it has been learned that SmB_6 is not only an insulator but also so called topological insulator. The interior of SmB_6 is insulator but the surface acts as a conductor. In their experiments Sebastian *et al* hoped to find additional evidence for the topological insulator property and attempted to measure quantum oscillations in the electrical resistance of their crystal sample. The variation of quantum oscillations as sample is rotated can be used to map out the Fermi surface of the crystal. No quantum oscillations were seen. The next step was to add magnetic field and just see whether something interesting happens and could save the project. Suddenly the expected signal was there! It was possible to detect quantum oscillations deep in the interior of the sample and map the Fermi surface! The electrons in the interior travelled 1 million times faster than the electrical resistance would suggest. Fermi surface was like that in copper, silver or gold. A further surprise was that the growth of the amplitude of quantum oscillations as temperature was decreased, was very different from the predictions of the universal Lifshitz-Kosevich formula for the conventional metals.

5.4.2 Could TGD help to understand the strange behavior of SmB_6?

There are several indications that the paradoxical effect might reveal the underlying dynamics of quantum TGD. The mechanism of conduction must represent new physics and magnetic field must play a key role by making conductivity possible by somehow providing the "current wires". How? The TGD based answer is completely obvious: magnetic flux tubes - one of the basic distinctions between electrodynamics of Maxwell and its TGD variant! Also the failure of Lischitz-Kosevich formulas should be understood.

1. Single sheet of many-sheeted space-time resembles topological insulator

One should also understand topological insulator property at deeper level, that is the conduction along the boundaries of topological insulator. One should understand why the current runs along 2-D surfaces. In fact, many exotic condensed matter systems are 2-dimensional in good approximation. In the models of integer and fractional quantum Hall effect electrons form a 2-D system with braid statistics possible only in 2-D system. High temperature super-conductivity is also an effectively 2-D phenomenon. By strong form of holography these aspects are also key aspects of quantum TGD at the fundamental level of single space-time sheet when the approximation replacing many-sheeted space-time with that of GRT and standard model does not mask the simplicity of the fundamental dynamics.

i. Many-sheeted space-time is second fundamental prediction TGD. The dynamics of single sheet of many-sheeted space-time should be very simple by the strong form of holography implyhing effective 2-dimensionality. The standard model description of this dynamics masks this simplicity since the sheets of many-sheeted space-time are replaced with single region of slightly curved Minkowski space with gauge potentials sums of induced gauge potentials for sheets and deviation of metric from Minkowski metric by the sum of corresponding deviations for space-time sheets. Could the dynamics of exotic condensed matter systems give a glimpse about the dynamics of single sheet? Could topological insulator and anyonic systems [K38] provide examples of this kind of systems?

ii. Second basic prediction of TGD is strong form of holography: string world sheets and partonic 2-surfaces serve as kind of "space-time genes" and the dynamics of fermions is 2-D at fundamental level. It must be however made clear that at QFT limit the spinor fields of embedding space replace these fundamental spinor fields localized at 2-surface. One might argue that the fundamental spinor fields do not make them directly visible in condensed matter physics. Nothing however prevents from asking whether in some circumstances the fundamental level could make itself visible.

In particular, for large h_{eff} dark matter systems (, whose existence can be deduced from the quantum criticality of quantum TGD) the partonic 2-surfaces with CP_2 size could be scaled up to nano-scopic and even longer size scales. I have proposed this kind of surfaces as carriers of electrons with non-standard value of h_{eff} in QHE and FQHE [K38].

The long range quantum fluctuations associated with large, $h_{eff} = n \times h$ phase would be quantum fluctuations rather than thermal ones. In the case of ordinary conductivity thermal energy makes it possible for electrons to jump between atoms and conductivity becomes very small at low temperatures. In the case of large scale quantum coherence just the opposite happens as observed. One therefore expects that Lifshitz-Kosevich formula for the temperature dependence of the amplitude does not hold true.

The generalization of Lifschitz-Kosevich formula to quantum critical case deduced from quantum holographic correspondence by Hartnoll and Hofman [D16] (`http://tinyurl.com/ybednd85` is expected to hold true qualitatively also for quantum criticality in TGD sense. The first guess is that by underlying super-conformal invariance scaling laws typical for critical systems hold true. In the proposed

formula the dependence on temperature is via a power of dimensionless parameter $x = T/mu$;, where μ is chemical potential for electron system. As a matter fact, exponent of power of x appears and reduces to first for Lifshitz-Konsevich formula. Since magnetic field is important, one also expects that the ratio of cyclotron energy scale $E_c \propto \hbar_{eff} eB/m_e$ to Fermi energy appears in the formula. One can even make an order of magnitude guess for the value of $h_{eff}/h \sim 10^6$ from the facts that the scale of conduction and conduction velocity were millions times higher than expected.

Strings are 1-D systems and strong form of holography implies that fermionic strings connecting partonic 2-surfaces and accompanied by magnetic flux tubes are fundamental. At light-like 3-surfaces fermion lines can give rise to braids. In TGD framework AdS/CFT correspondence generalizes since the conformal symmetries are extended. This is possible only in 4-D space-time and for the embedding space $H = M^4 \times CP_2$ making possible to generalize twistor approach [K48].

iii. Topological insulator property means from the perspective of modelling that the action reduces to a non-abelian Chern-Simons term. The quantum dynamics of TGD at space-time level is dictated by Kähler action. Space-time surfaces are preferred extremals of Kähler action and for them Kähler action reduces to Chern-Simons terms associated with the ends of space-time surface opposite boundaries of causal diamond and possibly to the 3-D light-like orbits of partonic 2-surfaces. Now the Chern-Simons term is Abelian but the induced gauge fields are non-Abelian. One might say that single sheeted physics resembles that of topological insulator.

iv. The effect appears only in magnetic field. I have been talking a lot about magnetic flux tubes carrying dark matter identified as large h_{eff} phases: topological quantization distinguishes TGD from Maxwell's theory: any system can be said to possess "magnetic body", whose flux tubes can serve as current wires. I have predicted the possibility of high temperature super-conductivity based on pairs of parallel magnetic flux tubes with the members of Cooper pairs at the neighboring flux tubes forming spin singlet or triplet depending on whether the fluxes are have same or opposite direction.

Also spin and electric currents assignable to the analogs of spontaneously magnetized states at single flux tube are possible. The obvious guess is that the conductivity in question is along the flux tubes of the external magnetic field. Could this kind of conductivity explains the strange behavior of SmB_6. The critical temperature would be that in which the parallel flux tubes are stable. The interaction energy of spin with the magnetic field serves as a possible criterion for the stability if the presence of dark electrons stabilizes the flux tubes.

2. Magnetic flux tubes as dark current carriers in quantum criticality

The following represents an extremely childish attempt of a non-specialist to understand how the conductivity might be understood. The current carrying electrons at flux tubes near the top of Fermi surface are current carriers. $h_{eff} = n \times h$ and magnetic flux tubes as current wires bring in the new elements. Also in the standard situation one considers cylinder symmetric solutions of Schrödinger equation in external magnetic field and introduces maximal radius for the orbits so that formally the two situations seem to be rather near to each other. Physically the large h_{eff} and associated many-sheeted covering of space-time surface providing the current wire makes the situation different since the collisions of electrons could be absent in good approximation so that the velocity of charge carriers could be much higher than expected as experiments indeed demonstrate.

Quantum criticality is the crucial aspect and corresponds to the situation in which the magnetic field attains a value for which a new orbit emerges/disappears at the surface of the flux tube: in this situation dark electron phase with non-standard value of h_{eff} can be generated. This mechanism is expected to apply also in bio-superconductivity and to provide a general control tool for magnetic body.

i. Let us assume that flux tubes cover the whole transversal area of the crystal and there is no overlap. Assume also that the total number of conduction electrons is fixed, and depending on the value of h_{eff} is shared differently between transversal and longitudinal degrees of freedom. Large value of h_{eff} squeezes the electrons from transversal to longitudinal flux tube degrees of freedom and gives rise to conductivity.

ii. Consider first Schrödinger equation. In radial direction one has harmonic oscillator and the orbits are Landau orbits. The cross sectional area behaves like $\pi R^2 = n_T h_{eff}/2m\omega_c$ giving $n_T \propto 1/h_{eff}$. Increase of the Planck constant scales up the radii of the orbits so that the number of states in cylinder of given radius is reduced. Angular momentum degeneracy implies that the number of transversal states is $N_T = n_T^2 \propto 1/h_{eff}^2$. In longitudinal direction one has free motion in a box of length L with states labelled by integer n_L. The number of states is given by the maximum value N_L of n_L.

iii. If the total number of states is fixed to $N = N_L N_T$ is fixed and thus does not depend on h_{eff}, one has $N_L \propto h_{eff}^2$. Quanta from transversal degrees of freedom are squeezed to longitudinal degrees of freedom, which makes possible conductivity.

iv. The conducting electrons are at the surface of the 1-D "Fermi-sphere", and the number of conduction electrons is $N_{cond} \simeq dN/d\epsilon \times \delta\epsilon \simeq dN/d\epsilon T = NT/2\epsilon_F \propto 1/h_{eff}^4$. The dependence on h_{eff} does not favor too large values of h_{eff}. On the other hand, if scattering of electrons at flux tubes could be absent. The assumption $L \propto h_{eff}$ increases the range over which current can flow.

v. To get a non-vanishing net current one must assume that only the electrons at the second end of the 1-D Fermi sphere are current carriers. The situation would resemble that in semiconductor. The direction of electric field would induce symmetry breaking at the level of quantum states. The situation would be like that for a mass in Earth's gravitational field treated quantally and electrons would accelerate freely. Schrödinger equation would give rise to Airy functions as its solution.

3. Quantum critical quantum oscillations

What about quantum oscillations in TGD framework?

i. Quantum oscillation refers to de Haas-van Alphen effect (`http://tinyurl.com/yaaljv9j`) - an oscillation of the induced magnetic moment as a function of $1/B$ with period $\tau = 2\pi e/\hbar A$, where A is the area of the extremal orbit of the Fermi surface, in the direction of the applied field. The effect is explained to be due to the Landau quantization of the electron energy. I failed to really understand the explanation of this source and in my humble opinion the following arguments provide a clearer view about what happens.

ii. If external magnetic field corresponds to flux tubes, Fermi surface decomposes into cylinders parallel to the magnetic field since the motion in transversal degrees of freedom is along circles. In the above thought experiment also a quantization in the longitudinal direction occurs if the flux tube has finite length so that Fermi surface in longitudinal direction has finite length. One expects on basis of Uncertainty Principle that the area S of the cross section of Fermi cylinder in momentum space is given by $S \propto h_{eff}^2/\pi R^2$. This follows also from the equation of motion of electron in magnetic field. As the external magnetic field B is increased, the radii of the orbits decrease inside the flux tube, and in momentum space the radii increase.

iii. Why does the induced magnetic moment (magnetization) and other observables oscillate?

A. The simplest manner to understand this is to look at the situation at space-time level. Classical orbits are harmonic oscillator orbits in radial degree of freedom. Suppose that the area of flux tube is fixed and B is increased. The orbits have radius $r_n^2 = (n + 1/2) \times \hbar/eB$ and shrink. For certain field values

the flux $eBA = n\hbar$ corresponds to an integer multiple of the elementary flux quantum . of a new orbit at the boundary of the flux tube emerges if the new orbit is near the boundary of Fermi sphere providing the electrons. This is clearly a critical situation.

B. In de Haas- van Alphen effect the orbit $n+1$ for B has same radius as the orbit n for $1/B+\Delta(1/B)$: $r_{n+1}(1/B) = r_n(1/B+\Delta(1/B))$. This gives approximate differential equation with respect to n and one obtains $(1/B)(n) = (n+1/2)\times \Delta(1/B)$. $\Delta(1/B)$ is fixed from the condition the flux quantization. When largest orbit is at the surface of the flux, tube the orbits are same for $B(n)$ and $B(n+1)$, and this gives rise to the de Haas - van Alphen effect.

C. It is not necessary to assume finite radius for the flux tube, and the exact value of the radius of the flux tube does not play and important role. The value of flux tube radius can be estimated from the ratio of the Fermi energy of electron to the cyclotron energy. Fermi energy about .1 eV depending only on the density of electrons in the lowest approximation and only very weakly on temperature. For a magnetic field of 1 Tesla cyclotron energy is .1 meV. The number of cylinders defined by orbits is about $n = 10^4$.

iv. What happens in TGD Universe in which the areas of flux tubes identifiable as space-time quanta are finite? Could quantum criticality of the transition in which a new orbit emerges at the boundary of flux tube lead to a large h_{eff} dark electron phase at flux tubes giving rise to conduction?

A. The above argument makes sense also in TGD Universe for the ordinary value of Planck constant. What about non-standard values of Planck constant? For $h_{eff}/h = n$ the value of flux quantum is n-fold so that the period of the oscillation in de Haas - van Alphen effect becomes n times shorter. The values of the magnetic field for which the orbit is at the surface of the flux tube are however critical since new orbit emerges assuming that the cyclotron energy corresponds is near Fermi energy. This quantum criticality could give rise to a phase transition generating non-standard value of Planck constant.
What about the period $\Delta(1/B)$ For $h_{eff}/h = n$? Modified flux quantization for extremal orbits implies that the area of flux quantum is scaled up by n. The flux changes by n units for the same increment of $\Delta(1/B)$ as for ordinary Planck constant so that de Haas -van Alphen effect does not detect the phase transition.

B. If the size scale of the orbits is scaled up by $\sqrt{n}$ as the semiclassical formula suggests the number of classical orbits is reduced by a factor $1/n$ if the radius of the flux tube is not changed in the transition $h \to h_{eff}$ to dark phase. n-sheetedness of the covering however compensates this reduction.

C. What about possible values of h_{eff}/h? The total value of flux seems to give the upper bound of $h_{eff}/h = n_{max}$, where n_{max} is the value of magnetic flux for ordinary value of Planck constant. For electron and magnetic field for $B = 10$ Tesla and has $n \leq 10^5$. This value is of the same order as the rough estimate from the length scale for which anomalous conduction occurs.

Clearly, the mechanism leading to anomalously high conductivity might be the transformation of the flux tubes to dark ones so that they carry dark electrons currents. The observed effect would be dark, quantum critical variant of de Haas-van Alphen effect!

Also bio-superconductivity is quantum critical phenomenon and this observation would suggests sharpening of the existing TGD based model of bio-super-conductivity. Super-conductivity would occur for critical magnetic fields for which largest cyclotron orbit is at the surface of the flux tube so that the system is quantum critical. Quantization of magnetic fluxes would quantify the quantum criticality. The variation of magnetic field strength would serve as control tool generating or eliminating supra currents. This conforms with the general vision about the role of dark magnetic fields in living matter.

To sum up, a breakthrough of TGD is continuing. I have written about thirty articles during this year - more than one article per week. There is huge garden there and trees contain fruits hanging low! It is very easy to pick them: just shatter and let them drop to the basket! New experimental anomalies having a nice explanation using TGD based concepts appear on weekly basis and the mathematical and physical understanding of TGD is taking place with great leaps. It is a pity that I must do all alone. I would like to share. I can only hope that colleagues could take the difficult step: admit what has happened and make a fresh start.

5.5 Quantization of thermal conductance and quantum thermodynamics

The finnish research group led by Mikko Möttönen working at Aalto University has made several highly interesting contributions to condensed matter physics during last years (see `http://tinyurl.com/yartleg2` about condensed matter magnetic monopoles and `http://tinyurl.com/jd26rhy` about tying quantum knots: both contributions are interesting also from TGD point of view). This morning I read about a new contribution published in Nature [D12] (see `http://tinyurl.com/y7bfzsnh`). One can find also a popular article telling about the finding (see `http://tinyurl.com/yba239d7`).

What has been shown in the recent work is that quantal thermal conductivity is possible for wires of 1 meter when the heat is transferred by photons. This length is by a factor 10^4 longer than in the earlier experiments. The improvement is amazing and the popular article tells that it could mean a revolution in quantum computations since heat spoling the quantum coherence can be carried out very effectively and in controlled manner from the computer (see `http://tinyurl.com/yba239d7`). Quantal thermal conductivity means that the transfer of energy along wire takes place without dissipation.

To understand what is involved consider first some basic definitions. Thermal conductivity k is defined by the formula $j = k\nabla T$, where j is the energy current per unit area and T the temperature. In practice it is convenient to use thermal power obtained by integrating the heat current over the transversal area of the wire to get the heat current dQ/dt as analog of electric current I. The thermal conductance g for a wire allowing approximation as 1-D structure is given by conductivity divided by the length of the wire: the power transmitted is $P = g\Delta T$, $g = k/L$.

One can deduce a formula for the conductance at the limit when the wire is ballistic meaning that no dissipation occurs. For instance, superconducting wire is a good candidate for this kind of channel and is used in the measurement. The conductance at the limit of quantum limited heat conduction (see `http://tinyurl.com/y7dtfrvt`) is an integer multiple of conductance quantum $g_0 = k_B^2\pi^2 T/3h$: $g = ng_0$. Here the sum is over parallel channels. What is remarkable is quantization and independence on the length of the wire. Once the heat carriers are in wire, the heat is transferred since dissipation is not present.

A completely analogous formula holds true for electric conductance along ballistic wire (see `http://tinyurl.com/y8gheqw6`): now g would be integer multiple of $g_0 = \sigma/L = 2e^2/h$. Note that in 2-D system quantum Hall conductance (not conductivity) is integer (more generally some rational) multiple of $\sigma_0 = e^2/h$. The formula in the case of conductance can be "derived" heuristically from Uncertainty Principle $\Delta E\Delta t = h$ plus putting $\Delta E = e\Delta V$ as difference of Coulomb energy and $\Delta t = q/I = qL/\Delta V = e/g_0$.

The essential prerequisite for quantal conduction is that the length of the wire is much shorter than the wavelength assignable to the carrier of heat or of thermal energy: $\lambda \gg L$. It is interesting to find how well this condition is satisfied in the recent case.

The wavelength of the photons involved with the transfer should be much longer than 1 meter. An order of magnitude for the energy of photons involve and thus for the frequency and wavelength can be deduced from the thermal energy of photons in the system. The electron temperatures considered are in the range of 10-100 mK roughly.

Kelvin corresponds to 10^{-4} eV (this is more or less all that I learned in thermodynamics course in student days) and eV corresponds to 1.24 microns. This temperature range roughly corresponds to energy range of $10^{-6} - 10^{-5}$ eV. The wave wavelength corresponding to maximal intensity of blackbody radiation is in the range of 2.3-23 centimeters. One can of course ask whether the condition $\lambda \gg L = 1$ m is consistent with this. A specialist would be needed to answer this question. Note that the gap energy .45 meV of superconductor defines energy scale for Josephson radiation generated by super-conductor: this energy would correspond to about 2 mm wavelength much below one 1 meter. This energy does not correspond to the energy scale of thermal photons.

I am of course unable to say anything interesting about the experiment itself but cannot avoid mentioning the hierarchy of Planck constants. If one has $E = h_{eff}f$, $h_{eff} = n \times h$ instead of $E = hf$, the condition $\lambda \gg L$ can be easily satisfied. For superconducting wire this would be true for superconducting magnetic flux tubes in TGD Universe and maybe it could be true also for photons, if they are dark and travel along them. One can even consider the possibility that quantal heat conductivity is possible over much longer wire lengths than 1 m. Showing this to be the case, would provide strong support for the hierarchy of Planck constants.

There are several interesting questions to be pondered in TGD framework. Could one identify classical space-time correlates for the quantization of conductance? Could one understand how classical thermodynamics differs from quantum thermodynamics? What quantum thermodynamics could actually mean? There are several rather obvious ideas.

i. Space-time surfaces are preferred extremals of Kähler action satisfying extremely powerful conditions boiling down to strong form of holography stating that string world sheets and partonic 2-surfaces basically dictate the classical space-time dynamics [K5, K54, K43]. Fermions are localized to string world sheets from the condition that electromagnetic charge is well-defined for spinor modes (classical W fields must vanish at the support of spinor modes).

   This picture is blurred as one goes to GRT-standard model limit of TGD and space-time sheets are lumped together to form a region of Minkowski space with metric which deviates from Minkowski metric by the sum of the deviations of the induced metrics from Minkowski metric. Also gauge potentials are defined as sums of induced gauge potentials. Classical thermodynamics would naturally correspond to this limit. Obviously the extreme simplicity of single sheeted dynamics is lost.

ii. Magnetic flux tubes to which one can assign space-like fermionic strings connecting partonic 2-surfaces are excellent candidates for the space-time correlates of wires and at the fundamental level the 1-dimensionality of wires is exact notion at the level of fermions. The quantization of conductance would be universal phenomenon blurred by the GRT-QFT approximation.

   The conductance for single magnetic flux tube would be the conductance quantum determined by preferred extremal property, by the boundary conditions coded by the electric voltage for electric conduction and by the temperatures for heat conduction. The quantization of conductances could be understood in terms of preferred extremal property. m-multiple of conductance would correspond to m flux tubes defining parallel wires. One should check whether also fractional conductances coming as rational m/n are possible as in the case of fractional quantum Hall effect and assignable to the hierarchy of Planck constants $h_{eff} = n \times h$ as the proportionality of quantum of conductance to $1/h$ suggests.

iii. One can go even further and ask whether the notion of temperature could make sense at quantum level. Quantum TGD can be regarded formally as a "complex square root" of thermodynamics. Single particle wave functions in Zero Energy Ontology (ZEO) can be regarded formally as "complex square roots" of thermodynamical partition functions and the analog of thermodynamical ensemble is realized by modulus squared of single particle wave function.

In particular, p-adic thermodynamics used for mass calculations can be replaced with its "complex square root" and the p-adic temperature associated with mass squared (rather than energy) is quantized and has spectrum $T_p = log(p)/n$ using suitable unit for mass squared [K27].

Whether also ordinary thermodynamical ensembles have square roots at single particle level (this would mean thermodynamical holography with members of ensemble representing ensemble!) is not clear. I have considered the possibility that cell membrane as generalized Josephson junction is describable using square root of thermodynamics [L4]. In ZEO this would allow to describe as zero energy states transitions in which initial and final states of event corresponding to zero energy state have different temperatures.

Square root of thermodynamics might also allow to make sense about the idea of entropic gravity, which as such is in conflict with experimental facts [K50] .

5.6 Are monopoles found?

LNC scientist report of having discovered magnetic monopoles (see `http://tinyurl.com/ppquxyy` and `http://tinyurl.com/y95zbuew`). The claim that free monopoles are discvoered are discovered is to my opinion too strong.

TGD allows monopole fluxes but no free monopoles. Wormhole throats however behave effectively like monopoles when looked at either space-time sheet, A or B. The first TGD explanation that comes in mind is in terms of 2-sheeted structures with wormhole contacts at the ends and monopole flux tubes connecting the wormhole throats at A and B so that closed monopole flux is the outcome. All elementary particles are predicted to be this kind of structures in the scale of Compton length. First wormhole carries throat carries the elementary particle quantum numbers and second throat neutrino pair neutralizing the weak isospin so that weak interaction is finite ranged. Compton length scales like h_{eff} and can be nano-scopic or even large for large values of h_{eff}. Also for abnormally large p-adic length scale implying different mass scale for the particle, the size scale increases.

How to explain the observations? Throats with opposite apparent quantized magnetic charges at given space-time sheet should move effectively like independent particles (although connected by flux tube) in opposite directions to give rise to an effective monopole current accompanied by an opposite current at the other space-time sheet. This is like having balls at the ends of very soft strings at the two sheets. One must assume that only the current only at single sheet is detected. It is mentioned that ohmic component corresponds to effectively free monopoles (already having long flux tubes connecting throats with small magnetic string tension). In strong magnetic fields shorter pairs of monopoles are reported to become "ionized" and give rise to a current increasing exponentially as function of square root of external magnetic field strength. This could correspond to a phase transition increasing h_{eff} with no change in particle mass. This would increase the length of monopole flux tube and the throats would be effectively free magnetic charges in much longer Compton scale.

The analog of color de-confinement comes in mind and one cannot exclude color force since non-vanishing Kähler field is necessarily accompanied by non-vanishing classical color gauge fields. Effectively free motion below the length scale of wormhole contact would correspond to asymtotic freedom. Amusingly, one would have zoomed up representation of dynamics of colored objects! One can also consider interpretation in terms of Kähler monopoles: induced Kähler form corresponds to classical electroweak U(1) field coupling to weak hypercharge but asymptotic freedom need not fit with this interpretation. Induced gauge fields are however strongly constrained: the components of color gauge fields are proportional to Hamiltonians of color rotation and induced Kähler form. Hence it is difficult to draw any conclusions.

5.7 Badly behaving photons and space-time as 4-surface

There was an interesting popular article with title *Light Behaving Badly: Strange Beams Reveal Hitch in Quantum Mechanics* (see `http://tinyurl.com/hefhdad`). The article told about a discovery made by a group of physicists at Trinity College Dublin in Ireland in the study of helical light-beams with conical geometry. These light beams are hollow and have the axis of helix as a symmetry axis. The surprising finding was that according to various experimental criteria one can say that photons have spin $S = \pm 1/2$ with respect to the rotations around the axis of the helix [L12] (see `http://tinyurl.com/zoro4gz`).

The first guess would be that this is due to the fact that rotational symmetry for the spiral conical beam is broken to axial rotational symmetry around the beam axis. This makes the situation 2-dimensional. In $D = 2$ one can have braid statistics allowing fractional angular momentum for the rotations around a hole - now the hollow interior of the beam. One can however counter argue that photons with half odd integer braid spin should obey Fermi statistics. This would mean that only one photon with fixed spin is possible in the beam. Something seems to go wrong with the naïve argument. It would seem that the exchange of photons does not seem to correspond to 2π rotation as a homotopy would be the topological manner to state the problem.

The authors of the article suggest that besides the ordinary conserved angular momentum one can identify also second conserved angular momentum like operator.

i. The conserved angular momentum is obtained as the replacement

$$J = L + S \to J_\gamma = L + \gamma S \quad . \tag{5.6}$$

ii. The eigenvalue equation for j_γ for a superposition of right and left polarizations with $S = \pm 1$

$$a_1 \times e_R exp(il_1\theta) + a_2 \times e_L exp(il_2\theta) \quad , \tag{5.7}$$

where l_i and also $s_z = \pm 1$ are integers, makes sense for

$$\gamma = \frac{(l_1 - l_2)}{2} \quad , \tag{5.8}$$

and gives eigenvalue

$$j_\gamma = \frac{l_1 + l_2}{2} \quad . \tag{5.9}$$

Since l_1 and l_2 are integers by the continuity of the wave function at 2π (even this can be questioned in hollow conical geometry) $(l_1 + l_2)/2$ and $(l_1 - l_2)/2$ are either integers or half integers. For $l_1 - l_2 = 1$ the one has $J_\gamma = J_{1/2} = L + S/2$, which is half odd integer. The stronger statement would be that 2-D $S_\gamma = S/2$ is half-odd integer.

There is an objection against this interpretation. The dependence of the angular momentum operator on the state of photon implied by $\gamma = (l_1 - l_2)/2$ is a highly questionable feature. Operators should not depend on states but define them as their eigenstates. Could one understand the experimental findings in some different manner? Could the additional angular momentum operator allow some natural interpretation? If it really generates rotations, where does it act?

In TGD framework this question relates interestingly to the assumption that space-time is 4-surface in $M^4 \times CP_2$. Could X^4 and M^4 correspond to the two loci for

the action of rotations? One can indeed have two kinds of photons. Photons can correspond to space-time sheets in $M^4 \times CP_2$ or they can correspond to space-time sheets topologically condensed to space-time surface $X^4 \subset M^4 \times CP_2$. For the first option one would have ordinary quantization of angular momentum in M^4. For the second option quantization in X^4 angular momentum, which using the units of M^4 angular momentum could correspond to half-integer or even more general quantization.

i. For the first (photons in M^4) option angular momentum $J(M^4) = L(M^4)+S(M^4)$ acts at point-like limit on a wave function of photon in M^4. $J(M^4)$ acts as a generator of rotations in M^4 should have the standard properties: in particular photon spin is $S = +/-1$.

ii. For topologically condensed photons at helix the angular momentum operator $J(X^4) = L(X^4) + S(X^4)$ generates at point-like limit rotations in X^4. If M^4 coordinates - in particular angle coordinate ϕ around helical axis - are used for X^4, the identifications

$$J(X^4) = kJ(M^4) \ , \quad L(X^4) = kL(M^4) \ , \quad S(X^4) = kS(M^4) \ . \tag{5.10}$$

are possible.

iii. In the recent case X^4 corresponds to effectively a helical conical path of photon beam, which is effectively 2-D system with axial $SO(2)$ symmetry. The space-time surface associated with the helical beam is analogous to a covering space of plane defined by Riemann surface for $z^{1/n}$ with origin excluded (hollowness of the spiral beam is essential since at z-axis various angles ϕ correspond to the same point and one would obtain discontinuity). It takes n full turns before one gets to the original point. This implies that $L(X^4) = kL(M^4)$ can be fractional with unit $\hbar/n$ meaning $k = 1/n$ when the angle coordinate of M^4 serves as angle coordinate of X^4.

iv. For $n = 2$ one has $k = 1/2$ and 4π rotations in Minkowski space interpreted as shadows of rotations at X^4 must give a phase equal to unity. This would allow half integer quantization for $J(X^4), L(X^4)$ and $S(X^4)$ of photon in M^4 units. $S(X^4)$ corresponds to a local rotation in tangent space of X^4. The braid rotation defined by a path around the helical axis corresponds to a spin rotation and by $k = 1/2$ to $S(X^4) = S(M^4)/2 = 1/2$. Hence one has effectively $S(M^4) = \pm 1/2$ for the two circular polarizations and thus $\gamma = \pm 1/2$ independently of l_i: in the above model $\gamma = (l_1 - l_2)/2$ can have also other values. Now also other values of n besides $n = 2$ are predicted.

   l_i can be both integer and half odd integer valued. One can reproduce the experimental findings for integer valued l_1 and l_2. One has $j = l_1 + 1/2 = l_2 - 1/2$ from condition that superpositions of both right and left-handed spiral photons are possible. If j is half-odd integer, $l_1 + l_2 = 2j$ is odd integer. For instance, $S(X^4) = 1/2$ gives $l_1 - l_2 = -1$ consistent with integer/half-odd integer property of both l_1 and l_2. For $j = 1/2$ one has $l_1 + l_2 = 1$ and $l_1 - l_2 = -1$ giving $(l_1, l_2) == (0, 1)$.

v. Is there something special in $n = 2$. In TGD elementary particles have wormhole contacts connecting two space-time sheets as building bricks. If the sheets form a covering of M^4 singular along plane M^2 one has $n = 2$ naturally.

One can worry about many-sheeted statistics. The intuitive view is that one just adds bosons/fermions at different sheets and each sheet corresponds to a discrete degree of freedom.

i. Statistics is not changed to Fermi statistics if the exchange interpreted at X^4 corresponds to $n \times 2\pi$ rotation. For $n = 2$ a possible modification of the anti-commutation relations would be doubling of oscillator operators assigning $a_k(i)$, $i = 1, 2$ to the 2 sheets and formulating braid anti-commutativity as

$$\begin{array}{lll} \{a_k(1), a_l(2)\} = 0 \ , & \{a_k^\dagger(1), a_l^\dagger(2)\} = 0 \ , & \{a_k^\dagger(1), a_l(2)\} = 0 \ . \\ [a_k(i), a_l(i)] = 0 & \left[a_k^\dagger(i), a_l^\dagger(i)\right] = 0 & \left[a_k^\dagger(i), a_l(i)\right] = \delta_{k,l} \ . \end{array} \tag{5.11}$$

This would be consistent with Bose-Einstein statistics. For n-sheeted case the formula replacing pair $(1,2)$ with any pair $(i, j \neq i)$ applies. One would have two sets of mutually commuting (creation) operators and these sets would anti-commute and Bose-Einstein condensates seem to be possible.

ii. One can worry about the connection with the hierarchy of Planck constants $h_{eff} = n \times h$, which is assigned with singular n-sheeted covering space. The 3-D surfaces defining ends of the covering at the boundaries of causal diamond (CD) would in this case co-incide. This might be the case now since the photon beam is assumed to be conical helix. Space-time surface would be analogous to n 3-D paths, which co-incide at their ends at past and future boundaries of CD.

Does the scaling of Planck constant by n compensate for the fractionization so that the only effect would be doubled Bose-Einstein condensate. It woud seem that these condensates need not have same numbers of photons. The scaling of cyclotron energies by n is central in the application of $h_{eff} = nh$ idea. It could be interpreted by saying that single boson state is replaced with n-boson state with the same cyclotron frequency but n-fold energy.

iii. In the fermionic case on obtain n additional degrees of freedom and ordinary single fermion state would be replaced with a set of states containing up to n fermions. This would lead to a kind of breakdown of fermion statistics possibly having interpretation in terms of braid statistics. And old question is whether one could understand quark color as $h_{eff}/h = n = 3$ braid statistics for leptons. At the level of CP_2 spinors em charge corresponds to sum of vectorial isospin and of anomalous color hypercharge which is for leptons $n = 3$ multiple of that for quarks. This could be perhaps interpreted in terms of scaling in hypercharge degree of freedom due to 3-sheeted covering. This picture does not seem however to work.

To sum up, also M^4 angular momentum and spin make sense and are integer valued but for the system identifiable as topological condensed photon plus helix rather than topological condensed photon at helix. Many-sheeted space-time can in principle rise to several angular momenta of this kind. Symmetry breaking go $SO(2)$ subgroup is however involved. The general prediction is $1/n$ fractionization.

Remark: I encountered a popular article (see `http://tinyurl.com/ybovyxd3`)about strange halving of photon angular momentum unit two years after writing the above comments. The immediate reaction was that the finding could be seen as a direct proof for $h_{eff} = nh_0$ hierarchy, where h_0 is the minimal value of Planck constants, which need not be ordinary Planck constant h as I have often assumed in previous writings.

Various arguments indeed support for $h = 6h_0$. This hypothesis would explain the strange findings about hydrogen atom having what Mills calls hydrino states having larger binding energy than normal hydrogen atom [L15] (see `http://tinyurl.com/goruuzm`): the increase of the binding energy would follow from the proportionality of the binding energy to $1/h_{eff}^2$. For $n_0 = 6 \to n < 6$ the binding energy is scale up as $(n/6)^2$. The values of $n = 1, 2, 3$ dividing n are preferred. Second argument supporting $h = 6h_0$ comes from the model for the color vision [L32] (see `http://tinyurl.com/y9jxyjns`).

What is the interpretation of the ordinary photon angular momentum for $n = n_0 = 6$? Quantization for angular momentum as multiples of $\hbar_0$ reads as $l = l_0\hbar_0 = (l_0/6)\hbar$, $l_0 = 1, 2...$ so that fractional angular momenta are possible. $l_0 = 6$ gives the ordinary quantization for which the wave function has same value for all 6 sheets of the covering. $l_0 = 3$ gives the claimed half-quantization.

5.8 Deviation from the prediction of standard quantum theory for radiative energy transfer in faraway region

I encountered in FB a highly interesting finding discussed in two popular articles (see http://tinyurl.com/yc64fmoo and http://tinyurl.com/yc9fwvnh). The original article (see http://tinyurl.com/y9kafhme) is behind paywall but one can find the crucial figure 5 online (see http://tinyurl.com/ybr87h7u) . It seems that experimental physics is in the middle of a revolution of century and theoretical physicists straying in superstring landscape do not have a slightest idea about what is happening.

The size scale of objects studied - membranes in temperature of order room temperature 300 Kfor instance - is about 1/2 micrometers: cell length scale range is in question. They produce radiation and other similar object is heated if there is temperature difference between the objects. The heat flow is proportional to the temperature difference and radiative conductance G_{rad} characterizes the situation. Planck's black body radiation law, which initiated the development of quantum theory for more than century ago, predicts G_{rad} at large enough distances.

i. The radiative transfer is larger than predicted by Planck's radiation law at *small distances* (nearby region) of order average wavelength of thermal radiation deducible from its temperature. This is not a news.

ii. The surprise was that radiative conductance is 100 times larger than expected from Planck's law at *large distances* (faraway region) for small objects with size of order .5 micron. This is a really big news.

The obvious explanation in TGD framework is provided by the hierarchy of Planck constants. Part of radiation has Planck constant $h_{eff} = n \times h_0$, which is larger than the standard value of $h = 6h_0$ (a good guess for atoms [L15, L32, L33]). This scales up the wavelengths and the size of nearby region scales like n. Faraway region can become effectively nearby region and conductance increases.

My guess is that this unavoidably means beginning of the second quantum revolution brought by the hierarchy of Planck constants. These experimental findings cannot be put under the rug anymore.

5.9 Time crystals, macroscopic quantum coherence, and adelic physics

Time crystals were (see http://tinyurl.com/jbj5j68 were proposed by Frank Wilzek in 2012. The idea is that there is a periodic collective motion so that one can see the system as analog of 3-D crystal with time appearing as fourth lattice dimension. One can learn more about real life time crystals at http://tinyurl.com/zy73t6r.

The first crystal was created by Moore *et al* (see http://tinyurl.com/js2h6b4) and involved magnetization. By adding a periodic driving force it was possible to generate spin flips inducing collective spin flip as a kind of domino effect. The surprise was that the period was twice the original period and small changes of the driving frequency did not affect the period. One had something more than forced oscillation - a genuine time crystal. The period of the driving force - Floquet period- was 74-75 μs and the system is measured for N=100 Floquet periods or about 7.4-7.5 milliseconds (1 ms happens to be of same order of magnitude as the duration of nerve pulse). I failed to find a comment about the size of the system. With quantum biological intuition I would guess something like the size of large neuron: about 100 micrometers.

Second law does not favor time crystals. The time in which single particle motions are thermalized is expected to be rather short. In the case of condensed matter systems the time scale would not be much larger than that for a typical rate of typical atomic transition. The rate for 2P $\rightarrow$ 1S transition of hydrogen atom estimated at http://tinyurl.com/jtze3kg gives a general idea. The decay rate is proportional to $\omega^3 d^2$, where $\omega = \Delta E/\hbar$ is the frequency difference corresponding to the energy difference

between the states, d is dipole moment proportional to αa_0, a_0 Bohr radius and $\alpha \sim 1/137$ fine structure constant. Average lifetime as inverse of the decay rate would be 1.6 ns and is expected to give a general order of magnitude estimate.

The proposal is that the systems in question emerge in non-equilibrium thermodynamics, which indeed predicts a master-slave hierarchy of time and length scales with masters providing the slowly changing background in which slaves are forced to move. I am not a specialist enough to express any strong opinions about thermodynamical explanation.

5.9.1 First TGD based impressions

What does TGD say about the situation?

i. So called Anderson localization (see `http://tinyurl.com/z9ems4o`) is believed to accompany time crystal. In TGD framework this translates to the fusion of 3-surfaces corresponding to particles to single large 3-surface consisting of particle 3-surfaces glued together by magnetic flux tubes. On can say that a relative localization of particles occurs and they more or less lose the relative translation degrees of freedom. This effect occurs always when bound states are formed and would happen already for hydrogen atom.

   TGD vision would actually solve a fundamental problem of QED caused by the assumption that proton and electron behave as independent point like particles: QED predicts a lot of non-existing quantum states since Bethe-Salpeter equation assumes degrees of freedom, which do not actually exist. Single particle descriptions (Schrödinger equation and Dirac equation) treating proton and electron effectively as single particle geometrically (rather than independent particles) having reduced mass gives excellent description whereas QED, which was thought to be something more precise, fails. Quite generally, bound states are not properly understood in QFTs. Color confinement problem is second example about this: usually it is believed that the failure is solely due to the fact that color interaction is strong but the real reason might be much deeper.

ii. In TGD Universe time crystals would be many-particle systems having collection of 3-surfaces connected by magnetic flux tubes (tensor network in terms of condensed matter complexity theory). Magnetic flux tubes would carry dark matter in TGD sense having $h_{eff}/h = n$ increasing the quantal scales - both spatial and temporal - so that one could have time crystals in long scales.

   Biology could provide basic examples. For instance, EEG resonance frequency could be associated with time crystals assignable to the magnetic body of brain carrying dark matter with large $h_{eff}/h = n$ - so large that dark photon energy $E = h_{eff}f$ would correspond to an energy above thermal energy. If bio-photons result from phase transitions $h_{eff}/h = n \to 1$, the energy would be in visible-UV energy range. These frequencies would in turn drive the visible matter in brain and force it to oscillate coherently.

iii. The time crystals claimed by Monroe and Lurkin to be created in laboratory demand a feed of energy (see `http://tinyurl.com/zm4m5v9`) unlike the time crystals proposed by Wilzek. The finding is consistent with the TGD based model. In TGD the generation of large h_{eff} phase demands energy. The reason is that the energies of states increase with h_{eff}. For instance, atomic binding energies decrease as $1/h_{eff}^2$. In quantum biology this requires feeding of metabolic energy. Also now interpretation would be analogous to this.

iv. Standard physics view would rely in non-equilibrium thermodynamics whereas TGD view about time crystals would rely on dark matter and hierarchy of Planck constants in turn implied by adelic physics suggested to provide a coherent description fusing real physics as physics of matter and various p-adic physics as physics of cognition.

   Number theoretical universality (NTU) leads to the notion of adelic space-time surface (monadic manifold) involving a discretization in an extension of rationals

defining particular level in the hierarchy of adeles defining evolutionary hierarchy. $h_{eff}/h = n$ has been identified from the beginning as the dimension of poly-sheeted covering assignable to space-time surface. The action of the Galois group of extensions indeed gives rise to covering space. The number n of sheets would be the dimension of the extension implying $h_{eff}/h = n$, which is bound to increase during evolution so that the complexity increases.

Indeed, since n is positive integer evolution is analogous to a diffusion in half-line and n unavoidably increases in the long run just as the particle diffuses farther away from origin (by looking what gradually happens near paper basket one understands what this means). The increase of n implies the increase of maximal negentropy and thus of negentropy. Negentropy Maximization Principle (NMP) follows from adelic physics alone and there is no need to postulate it separately. Things get better in the long run although we do not live in the best possible world as Leibniz who first proposed the notion of monad proposed!

5.9.2 Second look a couple of years later

5.9.3 Further comments on time crystals

Google has reported about a realization of a time crystal as a spin system. A rather hypish layman article (`https://cutt.ly/5QWZLWk`) creates the impression that perpetuum mobile has been discovered. Also the Quanta Magazine article (`https://cutt.ly/6QWZXfT`) creates this impression. The original research article [D10] (`https://cutt.ly/RQWZCSR`) provides a realistic description.

It is interesting to look at the situation in the TGD framework. From the abstract of the article also from the Wikipedia article about time crystals one learns that the system has periodic energy feed and is therefore not closed so that the finding is not in conflict with the second law and perpetuum mobile is not in question.

What is time crystal? The notion of time crystal (`https://cutt.ly/2n65xOk`) is a temporal analog of ordinary crystals in the sense that there is temporal periodicity, was proposed by Frank Wilczeck in 2012. Experimental realization was demonstrated in 2016-2017 but not in the way theorized by Wilczek. Soon also a no-go theorem against the original form of the time crystal emerged and motivated generalizations of Wilzeck's proposal.

The findings reported by Google are however extremely interesting. Very concisely, researchers study a spin system, which has two directions of magnetization and the external laser beam induces the system to oscillate between the two magnetization directions with a period, which is a multiple of the period of the laser beam. It is interesting to consider the system in TGD framework and I have actually discussed time crystals briefly in a recent article [L46].

i. Space-time surfaces as periodic minimal surfaces as counterparts of time crystals In TGD, classical physics is an exact part of quantum theory and quantum classical correspondence holds true. Hence it is interesting to consider first the situation at the classical space-time level. In TGD time crystals have as classical correlates space-time surfaces which are periodic minimal surfaces. It is possible to have analogs of time-crystals and also more general structures built as piles of lego like basic pieces in time direction bringing in mind sentences of language and DNA, which is quasi-periodic structure and more general than crystal.

ii. What about thermodynamics of time crystals? Could the time crystal be possible also in thermodynamic sense and even for thermodynamically closed systems? In the TGD framewoork, Negentropy Maximization Principle (NMP) [L44] and zero energy ontology (ZEO) [L40, L45] forces to generalize thermodynamics to allow both time arrows. ZEO is forced by TGD inspired theory of consciousness and solves the basic paradox of quantum measurement theory. The arrow of time would change in ordinary ("big") state function reduction (BSFR) and would remain

unaffected in "small" SFR (SSFR). Second law holds true at the level of real physics but in the cognitive sector information increases and NMP holds true.

Also new quantum theory might be needed to explain why the period is multiple of the driving period. The first possibly needed new element is hierarchy of effective Planck constants $h_{eff} = n \times h_0$ having number theoretical interpretation. h_{eff} measures the scale of quantum coherence and has also interpretation as the order of Galois group for a polynomial defining the space-time surface in M^8 mapped to $M^4 \times CP_2$ by $M^8 - H$ duality [L41, L42, L43].

The replacement of $h_{eff} \to kh_{eff}$ scales the periods by k and keeps energies unchanged. In TGD inspired biology h_{eff} hierarchy is in a crucial role and its levels behave relative to each other like dark matter.

In the recent case, the magnetic body (MB)of the spin system controlling its behavior would have $h_{eff} = nh_0$. Each period would be initiated by BSFR at the level of MB and change the arrow of time and induce effective change of it also at the level of the ordinary matter.

In ZEO, time crystal-like entities, which live in cycle by extracting back part of the energy that they have dissipated in a time reversed mode, are in principle possible. System "breathes". Various bio-rhythms could correspond to time crystals. The biological analogy is obvious and we know that life requires a metabolic energy feed: in TGD Universe it prevents the decrease of h_{eff} [L47].

For a thermodynamically open system, part of the dissipated energy leaks into the external world during each half cycle. Same happens in the time reversed mode and would mean that the system apparently receives positive energy also from the external world. Could this energy feed compensate for the energy loss to the external world by dissipation so that no external energy feed would be needed? Perhaps this might be the case in the ideal situation. One would have almost a perpetuum mobile! Periodic driving feeding energy to the system would be needed to take care that h_{eff} is not reduced.

5.10 Non-local production of photon pairs as support for $h_{eff}/h = n$ hypothesis

Again a new anomaly! Photon pairs have been created by a new mechanism. Photons emerge at different points (see `http://tinyurl.com/lseqyrq`).

Could this give support for the TGD based general model for elementary particle as a string like object (flux tube) with first end (wormhole contact) carrying the quantum numbers - in the case of gauge boson fermion and antifermion at opposite throats of the contact. Second end would carry neutrino-right-handed neutrino pair neutralizing the possible weak isospin. This would give only local decays. Also emissions of photons from charged particle would be local.

Could the bosonic particle be a mixture of two states. For the first state flux tube would have fermion and antifermion at the same end of the fluxtube: only local decays. For the second state fermion and antifermion would reside at the ends of the flux tubes residing at throats associated with different wormhole contacts. This state in state would give rise to non-local two-photon emissions. Mesons of hadron physics would correspond to this kind of states and in old-fashioned hadron physics one speaks about photon-vector meson mixing in the description of the photon-hadron interactions. If the Planck constant $h_{eff}/h = n$ of the emitting particle is large, the distance between photon emissions would be long. The non-local days could make the visible both exotic decay and allow to deduce the value of n! This would how require the transformation of emitted dark photon to ordinary (same would happen when dark photons transform to biophotons)

Can one say anything about the length of fux tube? Magnetic flux tube contains fermionic string. The length of this string is of order Compton length and of the order of p-adic length scale.

What about photon itself - could it have non-local fermion-antifermion decays based on the same mechanism? What the length of photonic string is is not clear. Photon is massless, no scales! One identification of length would be as wavelength defining also the p-adic length scale.

To sum up: the nonlocal decays and emissions could lend strong support for both flux tube identification of particles and for hierarchy of Planck constants. It might be possible to even measure the value of n associated with quantum critical state by detecting decays of this kind.

5.11 Exciton-polariton Bose-Einstein condensate at room temperature and h_{eff} hierarchy

Ulla gave in my blog (see `https://goo.gl/Yo3zQG`) a link to a very interesting work about Bose-Einstein condensation of quasi-particles known as exciton-polaritons. The `goo.gl/eKg13S`popular article tells about a research article [D13] (see `https://goo.gl/bZ6LFs`) published in Nature by IBM scientists.

Bose-Einstein condensation happens for exciton-polaritons at room temperature, this temperature is four orders of magnitude higher than the corresponding temperature for crystals. This puts bells ringing. Could $h_{eff}/h = n$ be involved?

One learns from Wikipedia (see `https://goo.gl/jLU7QG`) that exciton-polaritons are electron hole pairs- photons kick electron to higher energy state and exciton is created.These quasiparticles would form a Bose-Einstein condensate with large number of particles in ground state. The critical temperature corresponds to the divergence of Boltzmann factor given by Bose-Einstein statistics.

i. The energy of excitons must be of order thermal energy at room temperature: IR photons are in question. Membrane potential happens to corresponds to this energy. That the material is organic, might be of relevance. Living matter involves various Bose-Einstein condensate and one can consider also excitons.

   As noticed the critical temperature is surprisingly high. For crystal BECs it is of order .01 K. Now by a factor 30,000 times higher!

ii. Does the large value of $h_{eff} = n \times h$ visible make the critical temperature so high? Here I must look at same Wikipedia article for BEC of quasiparticles. Unfortunately the formula for the density of quasiparticle density dn/dV at criticality is copied from source and contains several errors. Dimensions are completely wrong. The formulas should read

$$(\frac{dn}{dV})^{1/3} = \frac{(m_{eff}T_{cr})^{1/2}}{\hbar} \quad .$$

   (One can put Boltzmann constant $k_B = 1$ by using for temperature same units as for energy).

iii. The correct formula for the critical temperature T_{cr} reads as

$$T_{cr} = \frac{\hbar^2(\frac{dn}{dV})^{2/3}}{m_{eff}} \quad .$$

iv. In TGD one can generalize by replacing $\hbar$ with $\hbar_{eff} = n \times \hbar$ so that one has

$$T_{cr} \to n^2 T_{cr}.$$

   Critical temperature would be proportional to n^2 and the high critical temperature (room temperature) could be understood. In crystals the critical temperature is very low but in organic matter a large value of $n \sim 100$ could change the situation. $n \sim 100$ would scale up the atomic scale of 1 Angstrom as a coherence length of valence electron orbitals to cell membrane thickness about 10 nm. There would be one dark electron-hole pair per volume taken by dark valence electron: this would look reasonable.

One must consider also the conservative option $n = 1$. T_{cr} is also proportional to $(dn/dV)^2$, where dn/dV is the density of excitons and to the inverse of the effective mass m_{eff}. m_{eff} must be of order electron mass so that the density dn/dV or n is the critical parameter. In standard physics so high a critical temperature would require either large density dn/dV about factor 10^6 higher than in crystals.

Is this possible?

i. Fermi energy E_F is given by almost identical formula but with factor 1/2 appearing on the right hand side. Using the density dn_e/dV for electrons instead of dn/dV gives an upper bound for $T_{cr} \leq 2E_F$. E_F varies in the range 2-10 eV. The actual values of T_{cr} in crystals is of order 10^{-6} eV so that the density of quasi particles must be very small for crystals: $dn_{cryst}/dV \simeq 10^{-9} dn_e/dV$.

ii. For crystal the size scale L_{cryst} of the volume taken by quasiparticle would be 10^{-3} times larger than that taken by electron, which varies in the range $10^{1/3} - 10^{2/3}$ Angstroms giving the range $(220 - 460)$ nm for L_{cryst}.

iii. On the other hand, the thickness of the plastic layer is $L_{layer} = 35$ nm, roughly 10 times smaller than L_{cryst}. One can argue that $L_{plast} \simeq L_{layer}$ is a natural order of magnitude for L_{cryst} for quasiparticle in plastic layer. If so, the density of quasiparticles is roughly 10^3 times higher than for crystals. The $(dn/dV)^2$-proportionality of T_{cr} would give the factor $T_{cr,plast} \simeq 10^6 T_{cr,cryst}$ so that there would be no need for non-standard value of h_{eff}!

But is the assumption $L_{plast} \simeq L_{layer}$ really justified in standard physics framework? Why this would be the case? What would make the dirty plastic different from super pure crystal?

The question which option is correct remains open: conservative would of course argue that the now-new-physics option is correct and might be right.

5.12 New findings related to high Tc super-conductivity

I learned simultaneously about two findings related to high Tc super-conductivity. The first finding [D18] provides further evidence for high Tc superconductivity at room temperature and pressure. Skinner has made a strange observation about magnetic susceptibility as a function of temperature for two values of external magnetic field [D1] (see `http://tinyurl.com/yaxtjjp5`). What looks like noise is essentially same for the curves at the level of detail. Unless only pseudonoise is in question, the finding forces to ask whether the data are manipulated. TGD inspired explanation involving so called de Haas-van Alphen effect allows to understand how pseudo noise for certain pairs of value of external magnetic field could have same shape.

Second finding provides evidence for positive feedback in the transition to high Tc superconductivity. This inspires a proposal of a general TGD based mechanism of bio-control in which small signal can serve as a control knob inducing phase transition producing macroscopically quantum coherent large h_{eff} phases in living matter.

I have added to the text the discovery of BCS type super-conductivity in lantanium hydroxide at temperature of 250 K towards the end of 2018 together with TGD based explanation in terms of $h_{eff} = n \times h_0$ hypothesis.

5.12.1 High Tc superconductivity at room temperature and pressure

Indian physicists Kumar Thapa and Anshu Pandey have found evidence for superconductivity at ambient (room) temperature and pressure in nanostructures [D18] (see `http://tinyurl.com/ybqybvap`). There are also earlier claims about room temperature superconductivity that I have discussed in my writings [K10, K40, K41].

1. The effect and its TGD explanation

Here is part of the abstract of the article of Kumar Thapa and Anshu Pandey.

We report the observation of superconductivity at ambient temperature and pressure conditions in films and pellets of a nanostructured material that is composed of silver particles embedded into a gold matrix. Specifically, we observe that upon cooling below 236 K at ambient pressures, the resistance of sample films drops below 10^{-4} *Ohm, being limited by instrument sensitivity. Further, below the transition temperature, samples BCSome strongly diamagnetic, with volume susceptibilities as low as -0.056. We further describe methods to tune the transition to temperatures higher than room temperature.*

During years I have developed a TGD based model of high Tc superconductivity and of bio-superconductivity [K10, K40, K41] (see `http://tinyurl.com/yazy5kwt` and `http://tinyurl.com/y7dd4f9m`).

Dark matter is identified as phases of ordinary matter with non-standard value $h_{eff}/h = n$ of Planck constant [**?**, K37] ($h = 6h_0$ is the most plausible option [L15, L32]). Charge carriers are $h_{eff}/h_0 = n$ dark macroscopically quantum coherent phases of ordinary charge carriers at magnetic flux tubes along which the supra current can flow. The only source of dissipation relates to the transfer of ordinary particles to flux tubes involving also phase transition changing the value of h_{eff}.

This superconductivity is essential also for microtubules exhibit signatures for the generation of this kind of phase at critical frequencies of AC voltages serving as a metabolic energy feed providing for charged particles the needed energy that they have in $h_{eff}/h_0 = n$ phase [L3].

Large h_{eff} phases with same parameters than ordinary phase have typically energies large than ordinary phase. For instance. Atomic binding energies scale like $1/h_{eff}^2$ and cyclotron energies and harmonic oscillator energies quite generally like h_{eff}. Free particle in box is however quantum critical in the sense that the energy scale $E = \hbar_{eff}^2/2mL^2$ does not depend on the h_{eff} if one has $L \propto h_{eff}$. At space-time level this is true quite generally for external (free) particles identified as minimal 4-surfaces. Quantum criticality means independence on various coupling parameters.

What is interesting is that Ag and Au have single valence electron. The obvious guess would be that valence electrons BCSome dark and form Cooper pairs in the transition to superconductivity. What is interesting that the basic claim of a layman researcher David Hudson is that ORMEs or mono-atomic elements as he calls them include also Gold [H2]. These claims are not of course taken seriously by academic researchers. In the language of quantum physics the claim is that ORMEs behave like macroscopic quantum systems. I decided to play with the thought that the claims are correct and this hypothesis served later one of the motivations for the hypothesis about dark matter as large h_{eff} phases [K10, K18]: this hypothesis follows from adelic physics [L28, L29] (see `http://tinyurl.com/ycbhse5c`, which is a number theoretical generalization of ordinary real number based physics.

TGD explanation of high Tc superconductivity and its biological applications strongly suggest that a feed of "metabolic" energy is a prerequisite of high Tc superconductivity quite generally. The natural question is whether experimenters might have found something suggesting that the external energy feed - usually seen as a prerequisite for self-organization - is involved with high T_c superconductivity. During same day I got FB link to another interesting finding related to high Tc superconductivity in cuprates and suggesting positive answer to this question!

2. The strange observation of Brian Skinner about the effect

After writing the above comments I learned from a popular article (see `http://tinyurl.com/ybm8perx`) about and objection (see `http://tinyurl.com/yaxtjjp5`) by Brian Skinner [D1] challenging the claimed discovery [D18] (see `http://tinyurl.com/ybqybvap`). The claimed finding received a lot of attention and physicist Brian Skinner in MIT decided to test the claims. At first the findings look quite convincing to him. He however decided to look for the noise in the measured value of volume susceptibility χ_V. χ_V relates the magnetic field B in superconductor to the external magnetic field B_{ext} via the formulate $B = (1 + \chi_V)B_{ext}$ (in units with $\mu_0 = 1$ one has $B_{ext} = H$, where H is used usually).

For diamagnetic materials χ_V is negative since they tend to repel external magnetic fields. For superconductors one has $\chi_V = -1$ in the ideal situation. The situation is not however ideal and stepwise change of χ_V from $\chi_V = 0$ to χ_V to some negative value but satisfying $|\mu_V| < 1$ serves as a signature of high Tc superconductivity. Both superconducting and ordinary phase would be present in the sample.

Figure 3a of the article of authors gives χ_V as function of temperature for some values of B_{ext} with the color of the curve indicating the value of B_{ext}. Note that μ_V depends on B_{ext}, whereas in strictly linear situation it would not do so. There is indeed transition at critical temperature $T_c = 225$ K reducing $\chi_V = 0$ to negative value in the range $\chi_V \in [-0.05, -.06]$ having no visible temperature dependence but decreasing somewhat with B_{ext}.

The problem is that the fluctuations of χ_V for green curve ($B_{ext} = 1$ Tesla) and blue curve ($B_{ext} = 0.1$ Tesla) have the same shape. With blue curve only only shifted downward relative to the green one (shifting corresponds to somewhat larger dia-magnetism for lower value of B_{ext}). If I have understood correctly, the finding applies only to these two curves and for one sample corresponding to $Tc = 256$ K. The article reports superconductivity with Tc varying in the range [145,400] K.

The pessimistic interpretation is that this part of data is fabricated. Second possibility is that human error is involved. The third interpretation would be that the random looking variation with temperature is not a fluctuation but represents genuine temperature dependence: this possibility looks infeasible but can be tested by repeating the measurements or simply looking whether it is present for the other measurements.

3. TGD explanation of the effect found by Skinner

One should understand why the effect occurs only for certain pairs of magnetic fields strengths B_{ext} and why the shape of pseudo fluctuations is the same in these situations.

Suppose that B_{ext} is realized as flux tubes of fixed radius. The magnetization is due to the penetration of magnetic field to the ordinary fraction of the sample as flux tubes. Suppose that the superconducting flux tubes assignable 2-D surfaces as in high Tc superconductivity. Could the fraction of super-conducting flux tubes with non-standard value of h_{eff} - depends on magnetic field and temperature in predictable manner?

The pseudo fluctuation should have same shape as a function temperature for the two values of magnetic fields involved but not for other pairs of magnetic field strengths.

i. Concerning the selection of only preferred pairs of magnetic fields de Haas-van Alphen effect gives a clue. As the intensity of magnetic field is varied, one observes so called de de Haas-van Alphen effect (`http://tinyurl.com/hoywcnq`) used to deduce the shape of the Fermi sphere: magnetization and some other observables vary periodically as function of $1/B$ (for a model for the quantum critical variant of the effect see [D16]). In particular, this is true for χ_V.

   The value of P is

$$P_{H-A} \equiv \frac{1}{B_{H-A}} = \frac{2\pi e}{\hbar S_e} \quad , \tag{5.12}$$

   where S_e is the extremum Fermi surface cross-sectional area in the plane perpendicular to the magnetic field and can be interpreted as area of electron orbit in momentum space (for illustration see `http://tinyurl.com/y9zxhu9o`).

   De Haas-van Alphen effect can be understood in the following manner. As B increases, cyclotron orbits contract. For certain increments of $1/B$ $n+1$:th orbit is contracted to n:th orbit so that the sets of the orbits are identical for the values of $1/B$, which appear periodically. This causes the periodic oscillation of say magnetization. From this one learns that the electrons rotating at magnetic flux tubes of B_{ext} are responsible for magnetization.

ii. One can get a more detailed theoretical view about de Haas-van Alphen effect from the article of Lifschitz and Mosevich (see `http://tinyurl.com/yay3pg9b`). In a reasonable approximation one can write

$$\begin{aligned} P &= \frac{e\hbar}{m_e E_F} = \frac{4\alpha}{3^{2/3}\pi^{1/3}} \times \frac{1}{B_e} \ , \quad B_e \equiv \frac{e}{a_e}^2 = \frac{1}{x^2} \times 16 \text{ Tesla} \ , \\ a_e &= (\frac{V}{N})^{1/3} = xa \ , \qquad\qquad a = 10^{-10} \text{ m} \ . \end{aligned} \tag{5.13}$$

Here N/V corresponds to valence electron density assumed to form free Fermi gas with Fermi energy $E_F = \hbar^2(3pi^2N/V)^{2/3}/2m_e$. $a = 10^{-10}$ m corresponds to atomic length scale. $\alpha \simeq 1/137$ is fine structure constant. For P one obtains the approximate expression

$$P \simeq .15x^2 \text{ Tesla}^{-1} \ .$$

If the difference of $\Delta(1/B_{ext})$ for $B_{ext} = 1$ Tesla and $B_{ext} = .1$ Tesla correspond to a k-multiple of P, one obtains the condition

$$kx^2 \simeq 60 \ .$$

iii. Suppose that $B_{ext,1} = 1$ Tesla and $B_{ext,1} = .1$ Tesla differ by a period P of de Haas-van Alphen effect. This would predict same value of χ_V for the two field strengths, which is not true. The formula used for χ_V however holds true only inside given flux tube: call this value $\chi_{V,H-A}$.

The fraction f of flux tubes penetrating into the superconductor can depend on the value of B_{ext} and this could explain the deviation. f can depend also on temperature. The simplest guess is that two effects separate:

$$\chi_V = \chi_{V,H-A}(\frac{B_{H-A}}{B_{ext}}) \times f(B_{ext}, T) \ . \tag{5.14}$$

Here $\chi_{V,H-A}$ has period P_{H-A} as function of $1/B_{ext}$ and f characterizes the fraction of penetrated flux tubes.

iv. What could one say about the function $f(B_{ext}, T)$? $B_{H-A} = 1/P_{H-A}$ has dimensions of magnetic field and depends on $1/B_{ext}$ periodically. The dimensionless ratio $E_{c,H-A}/T$ of cyclotron energy $E_{c,H-A} = \hbar eB_{H-A}/m_e$ and thermal energy T and B_{ext} could serve as arguments of $f(B_{ext}, T)$ so that one would have

$$f(B_{ext}, T) = f_1(B_{ext})f_2(x) \quad , \ x = \frac{T}{E_{H-A}(B_{ext}))} \ . \tag{5.15}$$

One can consider also the possibility that $E_{c,H-A}$ is cyclotron energy with $\hbar_{eff} = nh_0$ and larger than otherwise. For $h_{eff} = h$ and $B_{ext} = 1$ Tesla one would have $E_c = .8$ K, which is same order of magnitude as variation length for the pseudo fluctuation. For instance, periodicity as a function of x might be considered.

If $B_{ext,1} = 1$ Tesla and $B_{ext,1} = .1$ Tesla differ by a period P one would have

$$\frac{\chi_V(B_{ext,1}, T)}{\chi_V(B_{ext,2}, T)} = \frac{f_1(B_{ext,1})}{f_1(B_{ext,2})} \tag{5.16}$$

independently of T. For arbitrary pairs of magnetic fields this does not hold true. This property and also the predicted periodicity are testable.

5.12.2 Transition to high Tc superconductivity involves positive feedback

The discovery of positive feedback in the transition to hight Tc superconductivity is described in the popular article "*Physicists find clues to the origins of high-temperature superconductivity*" (see `http://tinyurl.com/ybo89asd`). Haoxian Li *et al* at the University of Colorado at Boulder and the Ecole Polytechnique Federale de Lausanne have published a paper [D7] on their experimental results obtained by using ARPES (Angle Resolved Photoemission Spectroscopy) in Nature Communications (see `http://tinyurl.com/y7z2lbh7`).

The article reports the discovery of a positive feedback loop that greatly enhances the superconductivity of cupra superconductors. The abstract of the article is here.

> *Strong diffusive or incoherent electronic correlations are the signature of the strange-metal normal state of the cuprate superconductors, with these correlations considered to be undressed or removed in the superconducting state. A critical question is if these correlations are responsible for the high-temperature superconductivity. Here, utilizing a development in the analysis of angle-resolved photoemission data, we show that the strange-metal correlations don't simply disappear in the superconducting state, but are instead converted into a strongly renormalized coherent state, with stronger normal state correlations leading to stronger superconducting state renormalization. This conversion begins well above Tc at the onset of superconducting fluctuations and it greatly increases the number of states that can pair. Therefore, there is positive feedback—the superconductive pairing creates the conversion that in turn strengthens the pairing. Although such positive feedback should enhance a conventional pairing mechanism, it could potentially also sustain an electronic pairing mechanism.*

The explanation of the positive feedback in TGD TGD framework could be following. The formation of dark electrons requires "metabolic" energy. The combination of dark electrons to Cooper pairs however liberates energy. If the liberated energy is larger than the energy needed to transform electron to its dark variant it can transform more electrons to dark state so that one obtains a spontaneous transition to high Tc superconductivity. The condition for positive feedback could serve as a criterion in the search for materials allowing high Tc superconductivity.

The mechanism could be fundamental in TGD inspired quantum biology. The spontaneous occurrence of the transition would make possible to induce large scale phase transitions by using a very small signal acting therefore as a kind of control knob. For instance, it could apply to bio-superconductivity in TGD sense, and also in the transition of protons to dark proton sequences giving rise to dark analogs of nuclei with a scaled down nuclear binding energy at magnetic flux tubes explaining Pollack effect [L4] [L4]. This transition could be also essential in TGD based model of "cold fusion" [L20] based also on the analog of Pollack effect. It could be also involved with the TGD based model for the finding of macroscopic quantum phase of microtubules induced by AC voltage at critical frequencies [L3] (see `http://tinyurl.com/y6vxplt3`).

5.12.3 BCS super conductivity at almost room temperature

Towards the end of year 2018 I learned about the discovery of BCS type (ordinary) superconductivity at temperature warmer than that at North Pole (see `http://tinyurl.com/ybgphjmd`). The compound in question was Lantanium hydride LaH_{10}. Mihail Eremets and his colleagues found that it BCSame superconducting at temperature -23 C and high pressure 170 GPa about 1.6 million times the atmospheric pressure [D6].

The popular article proposed an intuitive explanation of BCS superconductivity, which was new to me and deserves to be summarized here. Cooper pairs would surf on sound waves. The position would correspond to a constant phase for the wave and the velocity of motion would be the phase velocity of the sound wave. The intensity of sound wave

would be either maximum or minimum corresponding to a vanishing force on Cooper pair. One would have equilibrium position changing adiabatically, which would conform with the absence of dissipation.

This picture would conform with the general TGD based vision inspired by Sheldrakes's findings and claims related to morphic resonance [L13] , and by the conjectured general properties of preferred extremals of the variational principle implied by twistor lift of TGD [L37]. The experimental discovery is of course in flagrant conflict with the predictions of the BCS theory. As the popular article tells, before the work of Eremets *et al* the maximum critical temperature was thought to be something like 40 K corresponding to -233 °C.

The TGD based view is that Cooper pairs have members (electrons) at parallel flux tubes with opposite directions of magnetic flux and spin and have non-standard value of Planck constant $h_{eff} = n \times h_0 = n \times h/6$ [L15, L32], which is higher than the ordinary value, so that Cooper pairs can be stable at higher temperatures. The flux tubes would have contacts with the atoms of the lattice so that they would experience the lattice oscillations and electrons could surf at the flux tubes.

The mechanism binding electrons to a Cooper pair should be a variant of that in BCS model. The exchange of phonons generates an attractive interaction between electrons leading to the formation of the Cooper pair. The intuitive picture is that the electrons of the Cooper pair can be thought of lying on a mattress and creating a dip towards which the other electron tends to move. The interaction of the flux tubes with the lattice oscillations inducing magnetic oscillations should generate this kind of interaction between electrons at flux tubes and induce a formation of a Cooper pair.

Isotope effect is the crucial test: the gap energy and therefore critical temperature are proportional the oscillation frequency ω_D of the lattice (Debye frequency) proportional to $1/\sqrt{M}$ of the mass M of the molecule in question and decreases with the mass of the molecule. One has lantanium-hydroxide, and can use an isotope of hydrogen to reduce the Debye frequency. The gap energy was found to change in the expected manner.

Can TGD inspired model explain the isotope effect and the anomalously high value of the gap energy? The naïve order of magnitude estimate for the gap energy is of form $E_{gap} = x\hbar_{eff}\omega_D$, x a numerical factor. The larger the value of $h_{eff} = n \times h_0 = n \times h/6$, the larger the gap energy. Unless the high pressure increases ω_D dramatically, the critical temperature 253 K would require $n/6 \sim T_{cr}/T_{max}(BCS) \sim 250/40 \sim 6$. Note that for this value the cyclotron energy $E_c = h_{eff}f_c$ is much below thermal energy for magnetic fields even in Tesla range so that the binding energy must be due to the interaction with phonons.

The high pressure is needed to keep lattice rigid enough at high temperatures so that indeed oscillates rather than "flowing". I do not see how this could prevent flux tube mechanism from working. Neither do I know, whether high pressure could somehow increase the value of Debye frequency to get the large value of critical temperature. Unfortunately, the high pressure (170 GPa) makes this kind of high Tc superconductors unpractical.

5.13 Quantum scarring from TGD point of view

I learned about very interesting phenomenon serving as a challenge for TGD. In quantum scarring the system does not thermalize as one might expect as the popular article "*Quantum scarring appears to defy universe's push for disorder*" describes (see `http://tinyurl.com/y2bo8r8y`). The experimental article by Bernien *et al* with title *Probing many-body dynamics on a 51-atom quantum simulator* [D4] (see `http://tinyurl.com/yykagmeu`) has the following abstract.

> *Controllable, coherent many-body systems can provide insights into the fundamental properties of quantum matter, enable the realization of new quantum phases and could ultimately lead to computational systems that outperform existing computers based on classical approaches. Here we demonstrate a method*

for creating controlled many-body quantum matter that combines deterministically prepared, reconfigurable arrays of individually trapped cold atoms with strong, coherent interactions enabled by excitation to Rydberg states. We realize a programmable Ising-type quantum spin model with tunable interactions and system sizes of up to 51 qubits. Within this model, we observe phase transitions into spatially ordered states that break various discrete symmetries, verify the high-fidelity preparation of these states and investigate the dynamics across the phase transition in large arrays of atoms. In particular, we observe robust many-body dynamics corresponding to persistent oscillations of the order after a rapid quantum quench that results from a sudden transition across the phase boundary. Our method provides a way of exploring many-body phenomena on a programmable quantum simulator and could enable realizations of new quantum algorithms.

There are many theoretical articles about MBQS. As an example I include the abstract of the article "*Quantum scarred eigenstates in a Rydberg atom chain: entanglement, breakdown of thermalization, and stability to perturbations*" by Turner *et al* [D15] (see `http://tinyurl.com/y54unclz`) serving as basis of TGD inspired considerations.

Recent realization of a kinetically constrained chain of Rydberg atoms by Bernien et al., [Nature (London) 551, 579 (2017)] resulted in the observation of unusual revivals in the many-body quantum dynamics. In our previous work [C. J. Turner et al., Nat. Phys. 14, 745 (2018)], such dynamics was attributed to the existence of "quantum scarred" eigenstates in the many-body spectrum of the experimentally realized model. Here, we present a detailed study of the eigenstate properties of the same model.

We find that the majority of the eigenstates exhibit anomalous thermalization: the observable expectation values converge to their Gibbs ensemble values, but parametrically slower compared to the predictions of the eigenstate thermalization hypothesis (ETH). Amidst the thermalizing spectrum, we identify nonergodic eigenstates that strongly violate the ETH, whose number grows polynomially with system size. Previously, the same eigenstates were identified via large overlaps with certain product states, and were used to explain the revivals observed in experiment.

Here, we find that these eigenstates, in addition to highly atypical expectation values of local observables, also exhibit sub-thermal entanglement entropy that scales logarithmically with the system size. Moreover, we identify an additional class of quantum scarred eigenstates, and discuss their manifestations in the dynamics starting from initial product states.

We use forward scattering approximation to describe the structure and physical properties of quantum scarred eigenstates. Finally, we discuss the stability of quantum scars to various perturbations. We observe that quantum scars remain robust when the introduced perturbation is compatible with the forward scattering approximation. In contrast, the perturbations which most efficiently destroy quantum scars also lead to the restoration of "canonical" thermalization.

The systems exhibiting quantum scarring (QS) thermalize very slowly or do not thermalize at all. Instead, the system returns to its original state periodically. This behavior does not conform with ergodicity stating that the system goes through all possible state during time evolution.

There are a lot of systems, which fail to be ergodic.

i. In integrable systems - for which TGD is an excellent candidate - all states starting from energy eigenstate have this recurrence property as isolated systems if the energies are commeasurate (rational multiples of same unit of energy). In the recent case only preferred states have this recurrence property.

   In the experimental situation one considers a quenched system: the initial state can be modelled as energy eigenstate of some Hamiltonian H_0 which is replaced with

$H = H_0 + H_1$ so that the state is not energy eigenstate anymore. Periodic behavior requires that the state is superposition of finite number of state with commensurate energies in the resolution considered. In the ideal situation the eigenstates of H are integer spaced so that they have the period of the ground state as common periodicity. Period increases if there are states with energies close to each other since states E and $E + \Delta E$ must satisfy $ET = n \times 2\pi$ and $\Delta E \times T = m \times 2\pi$ giving $T = m2\pi/\Delta E = (m/n) \times (E/\Delta E$.

ii. For spin glass [B11] the energy landscape is a fractal with valleys inside valleys, and the system ends down to some valley as it dissipates. The mountains of the energy landscape force the localization and the thermalization is prevented.

Some kind of dynamical localization is expected place in the situations in which only preferred states give rise to a quantum scar. Dynamical localization could due to genuinely quantal state repulsive exchange forces depending on the relative direction of spins of valence electrons of Rydberg atoms.

One can distinguish between quantum scarring (QS) and quantum many-body scarring (MBQS).

i. In QS the wave function of the particle concentrates along unstable periodic classical orbit. The less unstable the orbit is, the stronger the scarring is. The classical orbit makes itself visible as a quantum scar.

ii. In MBQS scarring is a generalization of quantum scarring and the state of many-particle system returns to the original one. In principle one can describe many-particle system wave-mechanically as single particle state in a higher-D configuration space so that in principle this does not bring anything new. MBQS has been observed in a 1-D lattice formed by Rydberg atoms and ordinary atoms so that configuration space is effectively discrete. Some atoms of this system at very low temperature are excited to what are believed to be Rydberg atoms with large value of principal quantum number n_P and therefore large radius. This requires energy because bound states energies are proportional to $1/n_P^2\hbar^2$.

Remark: "Believed to be" sounds strange but in TGD framework atoms for which valence electrons have nonstandard value of Planck constant $h_{eff} = nh_0$ can look like Rydberg atoms. For $h = 6h_0$ suggested by experiments of Randell Mills [L15] one would have $h_{eff} = nh/6$ so that one could have one can have fractional principal quantum number $n_{P,eff} = (nn_P)/6$: this provides a test for h_{eff} hypothesis using irradiation with corresponding frequencies. For $n = 6n_1$ one might fail to distinguish these states from Rydberg states since the radii of the states scale like $n_{P,eff}^2$. Large value of h_{eff} would make possible quantum coherence in long length scales and this could be highly relevant for integrability.

Eigenstate thermalization (EST) is an important notion. Eigenstate thermalization takes place by unitary time evolution, which usually generates a superposition of large number of states with same total quantum numbers, in particular energy. Single particle states have however varying energies and in the superposition single particle states get entangled. For sub-systems the density matrix is assumed to develop to a thermal density matrix. In particular, entanglement entropy is identified as thermal entropy. For QS and MBQS EST would occur very slowly or not at all.

In TGD framework one can consider two approaches to MBQS and QS. The general approach starting from the key ideas of TGD and the approach starting directly from the special properties of Rydberg atoms and their possible analogs with non-standard value of $h_{eff} > h$. The key question is whether MBQS is analogous to the periodicity in integrable systems with commeasurate energies.

5.13.1 General TGD based considerations

In the sequel I will briefly discuss some aspects of the basic principles of TGD with some associations to MBQS. Reader can however skip directly to the concrete proposal if this looks easier.

1. TGD as generalization of Wheeler's superspace approach and as geometrization of quantum physics

One could see TGD as a generalization of Wheeler's superspace approach and generalization of Einstein's geometrization program for physics. Integrability, quantum criticality, quantum classical correspondence, zero energy ontology, and hierarchy of Planck constants are the aspects of TGD, which seem to be relevant for MBQS.

i. There are excellent reasons to believe that TGD Universe is integrable and quantum critical system [K43, **?**] in very general sense. Also MBQS are conjectured to possess these properties. Quantum criticality would be responsible for the ground state degeneracy characterizing the model Hamiltonian of Turner *et al* [D15].

ii. TGD generalizes Einstein's vision about the geometrization of physics to the level of quantum physics. The basic geometric object is the "world of classical worlds" (WCW) consisting of pairs of 3-surfaces with members at opposite boundaries of a causal diamond (CD) and connected by preferred extremal of the action which for the twistor lift of TGD decomposes to a sum of so called Kähler action analogous to Maxwell action and a volume term, whose coefficient corresponds to cosmological constant.

   General Coordinate invariance implies holography in the sense that the these pairs of 3-surfaces as analogs of Bohr orbits are equivalent with the 4-D preferred extremals connecting them. Classical theory is an exact part of quantum TGD. Preferred extremals are minimal surfaces which fail to be such only at 2-D singular surfaces having identification as string world sheets and representing orbits of folds of a 3-surface [L37, L39].

   In zero energy ontology (ZEO) quantum state - called zero energy state - is a superposition of deterministic preferred extremals. Simplest zero energy states are superpositions with same eigenvalues of observables and total quantum numbers are conserved.

   Remark: Wave functions concentrated along periodic unstable classical orbits is central to QS. Superposition should be along unstable classical orbit. One could imagine that the state is superposition of 3-surfaces along classical orbit defined as slices obtained by intersecting with translate of either boundary of CD.

iii. Zero modes are a key element of TGD and correspond to the degrees of freedom, which do not contribute to WCW metric, which is thus degenerate. There would be states with the same total quantum numbers but different values of zero modes so that ground state degeneracy of the model of Turner *et al* [D15] could correspond to wave function in zero modes.

Also fermionic degrees of freedom are geometrized.

i. Fermions are geometrized in terms of WCW spinor structure [K54] with WCW gamma matrices expressible as linear combinations of fermionic oscillator operators for second quantized induced spinor fields. Many-fermion states correspond to the modes of WCW spinor field. This implies what I call super-symplectic symmetry as an extension of the symplectic symmetry acting as isometries of WCW necessary for the existence of Riemann connection in infinite-D context [K15, **?**] (for loop spaces this was shown by Freed [A2]). Formally many-fermion states are just modes of classical spinor field in WCW.

ii. Quantum-classical correspondence (QCC) implies that classical conserved Cartan charges and total fermionic charges are identical. Each particle in many-particle state corresponds near the boundaries of CD to "free particle" having single particle preferred extremal as correlate. One would have superposition of the collections of preferred extremals in the initial state. Superposition in entangled many-fermion state would correspond to a superposition of unions of corresponding 3-surfaces differing by translation and by properties correlating with other single particle quantum numbers.

Quantum state with given total quantum numbers such as energy as for (ETH) is superposition of several many-particle states in general since total quantum numbers are sums of those with varying single particle quantum numbers. At fundamental level this would hold true in fermionic degrees of freedom (bosons are composites of fermions and antifermions in TGD Universe). For MBQS there would be only 2 different orbits corresponding to ground state of atom and Rydberg atom: the electronic Bohr orbits as pieces of space-time surface would be different for these. Therefore the situation would be rather simple classically.

iii. The space-time surface - as opposed to 3-surfaces at the ends of CD - associated with many-particle system would be connected as analog of connected Feynman diagram and correspond to a formation of magnetic flux tubes between atoms as correlates of entanglement. The periodicity of the entanglement would correspond to periodic generation and disappearance of entanglement and flux tube - kind of breathing consisting of phase transitions between gas phase and liquid phase. Somewhat similar situation is encountered in simple systems consisting of plastic balls exhibiting basic aspects of life [L25].

2. Number theoretical vision

Number theoretical vision is second thread of TGD besides the vision about geometrization of physics.

i. p-Adic physics and their fusion to form a hierarchy of adelic physics characterized by a hierarchy of extensions of rational numbers inducing in turn extensions of various p-adic number fields [L29, L28]. Classical number fields represent second key aspect of number theoretical vision [L22].

   Adelic physics predicts a hierarchy $h_{eff} = nh_0$ ($h = 6h_0$ is a good guess [L15]) of effective values of Planck constant assumed to label a hierarchy of phases behaving like dark matter and having an interpretation as a dimension for extension of rationals.

ii. One can ask whether non-standard value of h_{eff} guaranteeing quantum coherence in scales longer than expected is involved with MBQS. One can ask whether Rydberg atoms be actually atoms with valence electrons, which are dark for some value of h_{eff} and have scaled orbits with scaling factor $(h_{eff}/h)^2 = (n/6)^2$. If n is not a multiple of 6, one can speak of fractional principal quantum number $n_P = n/6$ and this might allow to test the hypothesis. For $h_{eff} > h$ pseudo Rydberg electrons could form a nanoscopic quantum system.

   MBQS is observed in very low temperatures and one can argue that the ordinary value of Planck constant is enough. One can however wonder whether MBQS is possible at higher temperatures for non-standard value of h_{eff} just like high Tc superconductivity if it is due to large h_{eff}.

iii. If the presence of flux tube connections is necessary for large scale quantum coherence in the scale of the entire system needed and serves also as a correlate for entanglement, one can argue $h_{eff} > h$ is needed. Otherwise one expects thermalization to occur since the system decomposes to smaller quantum-coherent systems.

3. ZEO and generalization of quantum measurement theory

ZEO forces to generalize quantum measurement theory. One could also say that the need to solve the basic paradox of quantum measurement theory forces ZEO.

i. In ZEO state function reduction is replaced with the counterpart of ordinary state function reduction- "big state function reduction" (BSR) and the counterpart of weak measurement - "small state function reduction" (SSR) . The unitary evolution of state corresponds in TGD sequence of unitary evolutions followed by SSR affecting only the states at the active boundary of CD and also de-localizing the

active boundary whereas passive boundary and members of state pairs at it would remain unaffected.

SSR would localize the active boundary so that one has only single CD in superposition and mean also time measurement with time defined as the distance between the tips of CD. BSRs would change the roles of passive and active boundaries of CD and change the arrow of time assignable to the state by passive-active characterization.

ii. Are SSRs or BSRs associated with the reduction of entanglement and return to the initial state in MBQS? SSR looks a more plausible interpretation. BSR would reduce the entanglement at the active boundary making it passive and change the arrow of time and next BSR would bring back the original arrow of time and CD boundary would be slightly shifted towards future. It is not clear whether the entanglement is small in the beginning of sequence of SSRs.

5.13.2 A concrete TGD inspired model for MBQS

The fact that MBQS occurs only for special initial states forces to ask whether it reflects the special properties of the system considered or some general properties such as integrability for a system with commeasurate energies. Or is MBQS something between these two cases: could the property of having energy spectrum with energies coming as rational multiples of a fundamental be dynamically generated (localization)?

i. System could be an integrable system for which the evolution is periodic if energies are commensurate. The spectrum should not differ too much from harmonic oscillator spectrum since small energy differences tend to spoil the periodicity. There are excellent reasons to expect that TGD is integrable theory but the behavior resembling harmonic oscillator is not obvious.

The system is unstable and should be therefore critical and possess zero modes generating long range quantum fluctuations for which large h_{eff} phases can serve as correlates. This is achieved if ground state has a large degeneracy with respect to energy. Small perturbations can be always described in terms of harmonic oscillators. The frequencies of harmonic oscillators should be expressible as multiples of fundamentals whose ratios are rational numbers.

ii. In TGD framewor the large value of h_{eff} makes possible quantum coherence in longer length scales and commeasurate integrability in such a way that eigenenergies resemble harmonic oscillator spectrum coming as integer multiples of rather few rationally related fundamentals.

iii. Space-time sheet is a natural candidate for a quantum coherent structure and if the space-time sheet decomposes into smaller disjoint sheets also coherence would be lost. Magnetic flux tubes connecting smaller space-time sheets to larger units would be natural correlates of quantum coherence and carry large h_{eff} phases. One could perhaps speak of dynamically generated quantum coherence and integrability with small number of fundamental energies.

iv. Dynamical localization should occur and could be due to interatomic forces. Exchange forces due to the Fermi statistics generate spin-dependent interactions, which are short ranged and repulsive for parallel spins. The exchange forces are excellent candidates for inducing the localization.

Dark valence electrons with large h_{eff} would have stronger exchange forces. This would promote the localization since one could not have effective Rydberg atoms (ERAs) with too small distance between them. If one has a system consisting of ordinary atoms (OAs) plus ERAs, the dark valence electrons could form a macroscopic quantum having MBQS states for this reason.

The physical picture is that states in which ERAs have too small mutual distance are not possible. This gives a constraint to the dynamics. Typically the "spin

flip" giving rise to an ERA can occur only for atoms with sufficiently large distances to the nearest ERAs. This constraint dynamics forces localization inducing periodicity.

1. About intermolecular -, van der Waals -, and exchange forces

Intermolecular forces (see `http://tinyurl.com/mmxnctm`) include exchange forces due to Pauli exclusion principle, electrostatic interactions between permanent electric and magnetic multipoles, which can be both attractive and repulsive, and attractive interactions between permanent and induced multipoles - induction -, and between induced multipoles - so called dispersion forces.

In standard QFT van der Waals force-London dispersion force comes from interaction with zero point energy and analogous to Casimir force. London dispersion force is proportional to the product of ionization energies of atoms divided by their sum and product of polarizabilities and therefore proportional to $1/h_{eff}^2$ and would weaken for large h_{eff}.

Lennard-Jones potential (see `http://tinyurl.com/y9bjcxn5`) provides the simplest parameterization of these forces. There is attractive $1/r^6$ term representing dispersion forces and repulsive $1/r^{12}$ term interpreted in terms of exchange forces repulsive/attractive for parallel/opposite spins of electrons. This follows from antisymmetry of the wave function. The dispersion force if proportional to the energy scale of atom and therefore to $1/h_{eff}^2$ so that its scale decreases for large h_{eff}.

The strength of the exchange force is proportional to the inner product of spins and therefore proportional to h_{eff}^2 and increases with h_{eff}^2. This make increase the range of this force and together with the weakening of the dispersion force would make the radius at which the van der Waals force becomes repulsive larger. This would promote dynamical localization.

2. Consistency with the model of MBQS of Turner et al

In the model of MBQS discussed by by Turner *et al* [D15] (see `http://tinyurl.com/y54unclz`) the situation is indeed very much like proposed above. One considers a model Hamiltonian H having decomposition $H = H_0 + H_1$. Ground state and Rydberg state are formally described as two possible states of spin.

The first part in the Hamilton is sum $H_0 = k\sum X_i$ over single particle terms X_i analogous to paramagnetic spin flip term in the interaction of spins with an external magnetic field. It acts on single particle transforming ordinary atom in ground state to Rydberg atom or vice versa.

Second part $H_1 = \sum i \neq j V_{ij} Q^i Q^j$ of the Hamiltonian describes repulsive interatomic forces and is associated with pairs of particles at different sites. Individual terms are proportional to the projectors Q_i and Q_j to Rydberg states at neighboring sites i and j and the parameter V_{ij} describing interaction strength assumed to behave like $1/|i-j|^n$, $n = 6$, at the limit $i \to j$. Lennard-Jones potential would suggest $n = 12$ but this is not essential for the model since one considers an approximation in which only nearest neighbour interactions are considered. This part of the Hamiltonian is the large part non-perturbative and spin-flip term is treated as a small perturbation, which suggests that harmonic oscillator type approximation is good.

In nearest neighbour approximation the large part H_1 is proportional to a sum over terms $V_{i,i+1} Q_i Q_{i+1}$ over nearest neighbour pairs. In the states with minimum energy the positive interaction term (somewhat ironically) vanishes: this is guaranteed if all Rydberg sites have ground states as neighbours. One can introduce to the Hamilton this constraint explicitly, and by a scaling ends up to a Hamiltonian which is just the small paramagnetic spin flip term X_i multiplied from left *resp.* right side by projector P_{i-1} *resp.* P_{i+1} to the subspace satisfying the constraint.

The effect of this Hamiltonian is to induce "spin flips" such that the constraint is respected. The outcome is entangled state and the localization caused by the constraint induces the periodic dynamics and failure of ETH for preferred states.

The entanglement between dark and ordinary states makes sense: $h_{eff} = nh_0$ corresponds at space-time level n-sheeted covering of space-time. One must however assume that the entanglement coefficients are in the extension of rationals associated with the smaller value of n (n_1) belonging to that assignable to the larger value of n (n_2): therefore n_1 divides n_2.

If the effective spin-spin interaction is a sensible model for the situation, the value of h_{eff} affects only the parameters determining the spin-spin interaction. The excitation of ERAs requires energy but so does also the excitation of ordinary Rydberg atoms so that this cannot be used as an objection against the model.

5.14 Three surprising condensed matter findings

I learned about 3 surprising findings related to condensed matter physics and defying standard quantum theory and having a natural explanation in TGD framework.

5.14.1 The strange behavior of light

Light does not behave quite in the manner expected (see `http://tinyurl.com/sjc9rpu`). What was studied was splitting of photons to entangled pairs of photons in the crystal beam entering a crystal. Quantum field theory based on the idea of completely point-like particle predicts that photon pairs should be created at single point. What was observed that members of entangled photon pairs can be also created at separate points. The distances of these points can be about 1/100 microns- which happens to the size scale of cell membrane and fundamental scale in living matter. This length scale is about 100 times the atomic length scale.

Researchers argue that this findings supports new kind of Uncertainty Principle. I do not feel quite easy with this proposal unless it is taken to mean that particle has geometric size to be distinguished from Compton length.

i. In TGD Universe geometric size would be due to the fact that particles are not point-like but correspond to 3-D surfaces whose "orbits" define basic building bricks of space-time as 4-D surface in 8-D space-time $H = M^4 \times CP_2$. Particles can exiss superpositions of their variants with different size scales.

ii. p-Adic physics for various primes p fusing together with real number based physics to what I call adelic physics would provide physical correlates of cognition and sensory experience. The number theoretic vision assigns to each particle extension of rationals characterized by so called ramified primes, which are excellent candidates for defining preferred p-adic length scales. The dimension n of extension defining a measure for algebraic complexity and serving as a kind of universal IQ has interpretation as effective Planck constant $h_{eff}/h_0 = n$ so that a connection with quantum physics - or rather its TGD based generalization - emerges.

iii. p-adic mass calculations rely on p-adic length scale hypothesis stating that primes near powers of 2 are especially interesting physically and massive elementary particles and also hadrons correspond to this kind of primes. p-Adic mass scale would be proportional to $p^{1/2}$.

A lot of new physics is predicted.

i. TGD predicts scaled variants of strong and weak interaction physics corresponding to different values of p and LHC provides handful of bumps having identification as scaled variants of ordinary hadrons and having mass which is 512 higher [K30].

ii. For given particle several mass scales are in principle allowed. Quite generally, particle can correspond to several p-adic primes and therefore can exist in states with different masses differing by power of $2^{1/2}$. The existence of this kind of states in the case of neutrinos would solve some problems related to neutrinos and their masses.

iii. In the case of massless particles different p-adic mass scales do not mean that masses are different (or more precisely, the masses depend on p but are extremely small and below measurement resolution so that mass differences cannot be detected). The p-adic length scale defines the geometric size of the particle as 3-surface to be distinguished from quantum size defined by Compton length. Quantum classical correspondence (QCC) strongly suggests that these two scales are same or at least closely correlated.

The hierarchy of Planck constants $h_{eff} = n \times h_0$ having an interpretation in terms of dark variants of ordinary particles predicts second kind of scale hierarchy.

i. The mass of the dark variant of elementary particle would not differ from the mass of ordinary particle but Compton size for a dark particle is proportional to n - a good guess is that $n = 6$ would correspond to ordinary particle and ordinary value h of h_{eff}.

ii. The scales defined by dark matter hierarchy could relate to p-adic length scales. There could be kind of resonance coupling for massless particles: dark massless particle labelled by n and particle labelled by p-adic prime p could transform to each other with high rate if the p-adic and dark length scales are nearly the same. This could be very relevant for biology.

The experimental findings could be understood if photons can correspond to several p-adic length scales. The length scale 10 nm defining the upper bound for distance between members of entangled photon pair in experiments would correspond to p-adic length scale $L(151)$, which corresponds to Gaussian Mersenne prime $p = (1+i)^{151}-1$. A simple model for photon could be as a closed flux tube like structure of this length. Also $k = 157, 163$, and 167 define Gaussian Mersenne primes, which is a number theoretical miracle. What is fascinating that these scales are fundamental biological length scales assignable to the basic structures of DNA.

5.14.2 New surprises related to super-conductors

So called Anderson's theorem applying to the conventional super-conductors (BCS) states that the addition of non-magnetic impurities does not destroy super-conductivity. It has been however found (see `http://tinyurl.com/vq2do7f`) that this is not the case for iron based high Tc super-conductors. This gives a valuable hints in still-continuing to attempts to understand high Tc super-conductivity.

I have been preaching for fifteen years new kind of super-conductivity explaining high Tc superconductivity making living systems high Tc superconductors [K40, K41].

i. The TGD view about magnetic fields differs from Maxwellian view. The counterparts of Maxwellian magnetic fields are flux quanta, flux tubes or sheets realized as space-time surfaces (or regions of them). Besides counterparts of ordinary magnetic fields there are also monopole flux tubes and they appear in all scales and form the basis of entire TGD view of Universe. They carry dark matter as $h_{eff} = n \times h_0$ phases and for large value of $h_{eff} > h$ there is quantum coherence in long scales making possible super-conductivity along dark magnetic flux tubes. This could explain also high Tc superconductivity in iron based super-conductors.

ii. What was found that the addition of Cobalt atoms destroys the super-conductivity by inducing quantum phase transition. Anderson's theorem for ordinary superconductivity however states that non-magnetic perturbations do not affect superconductivity. In TGD framework the natural interpretation would be that the quantum phase transition reduces the value of $h_{eff}/h_0 = n$ and thus also the quantum coherence length meaning that flux tube length is reduces and superconductivity is possible only in short scales. Note that dark matter is identified as phases with non-standard value of h_{eff} different from h.

iii. Also the nature of so called energy gap assignable to super-conductors was modified as Cobalt atoms were gradually added to destroy super-conductivity. This is not surprising if the value of h_{eff} was reduced. The reduction of h_{eff} in general decreases energies for other parameters kept constant and now it would mean reduction of energy gap and loss of superconductivity.

5.14.3 Conductors of electricity, which are poor conductors of heat

The so called Wiedemann-Franz Law states that good conductors of electricity are also good conductors of heat. The two conductivities are proportional to each other. The metal found 2017 however violates this law (see `http://tinyurl.com/w4t9vdx`) Vanadium dioxide VO_2 transforms from insulator to a conductive metal at 67 degrees Celsius. The experimenters argue that this property could make possible new technologies. For instance, conversion of wasted heat from engines could be transformed to electricity.

Electrons are found to move in coordinated, synchronous manner and this would explain the reduction of heat conductivity to 1/10 of the expected value. There is no superconductivity however. TGD explanation would be in terms of coherence and synchrony induced from the quantum coherence of dark phases of matter having $h_{eff}/h_0 = n$ residing at the magnetic body of the system controlling it.

This forced coherence would be also crucial in living matter: ordinary living matter would not be quantum coherent but the magnetic body carrying dark matter would force the coherence. In fact, all self-organization processes could involve magnetic body and dark matter.

6 Biological Applications

6.1 Worrying About The Consistency With The TGD Inspired Quantum Biology

The life of theoretician trying to be worth of his salt is full of worrying: it is always necessary to make internal consistency checks. One of the worries is whether the hypothesis $\hbar_{eff} = n \times \hbar = \hbar_{gr} = GMm/v_0$ is really consistent with TGD inspired quantum biology or has wishful thinking made its way to the arguments? More precisely, does the nominal value $B_{end} = .2 \times 10^{-4}$ Tesla of "endogenous" magnetic field suggested by the effects of ELF em fields on brain give electron cyclotron energy $E = h_{eff}eB_{end}/2\pi m$ in few eV range for the value of n in question?

At the end of worry-filled section I have included two pieces of reckless speculation as the final relief.

6.1.1 Some background

First some background.

i. The identification $h_{eff} = h_{gr}$, where h_{gr} is what I call gravitational Planck constant

$$h_{gr} = \frac{GMm}{2\pi v_0} = \frac{r_S m}{4\pi\beta_0} \quad , \quad \beta_0 = \frac{v_0}{c} \tag{6.1}$$

makes the model quantitive. In the expression of h_{gr} M is the "large" mass - naturally Earth's mass M_E. m would be the mass of ^4He atom. $r_S = 2GM/c$ denotes Schwartschild radius of Earth, which from $M_E = 3 \times 10^{-6} M_{Sun}$ and from $r_S(Sun) = 3$ km is 4.5 mm. v_0 would be some characteristic velocity for Earth-superfluid system and the rotation velocity $v_0 = 465.1$ m/s of Earth is a good

candidate in this respect. Also the radius of Earth $R_E = 6.38 \times 10^6$ meters will be needed.

ii. One could fix the value of v_0 in the following manner. Consider the Schrödinger equation for particle in gravitational field of a massive object at vertical flux tubes carrying the gravitational interaction. The solutions are Airy functions which decay very fast above some critical distance z_0. Require that z_0 is apart from a numerical factor equal to Earth radius. This condition predicts the value of v_0 which is consistent in the case of Earth and Sun with earlier hypothesis about their values. For Sun v_0 would be 5.65×10^{-4}c and for Earth orbital rotation velocity β_0 scaled up from 1.6×10^{-6} to 2.3×10^{-6} by a factor $1.41 \simeq \sqrt{2}$.

iii. In TGD inspired biology the hypothesis $h_{gr} = h_{eff} = n \times h$ plays a key role. One of the basic implications is that the energies of cyclotron photons associated with magnetic flux tubes have universal energy spectrum since the dependence on the mass of the charged particle disappears. Also the gravitational Compton length. The gravitational Compton length $\lambda_{gr} = h_{gr}/m$ does not depend on the mass of the particle and equals to $\lambda_{gr} = GM/v_0 \simeq 645$ meters in the recent case. The scale of the superfluid system is thus much smaller than the coherence length.

iv. Note that the nominal value of B_{end} is definitely not the only value in the spectrum of B_{end}. Already the model of hearing forces to allowing spectrum of about 10 octaves (3 orders of magnitude) corresponding the spectrum of audible frequencies. Also the geometric model of harmony correlating music and genetic code requires this.

6.1.2 Does $h_{gr} = h_{eff}$ hypothesis predict that the energy range of dark photons is that of biophotons?

Consider now the question whether the predicted value of n is consistent with the assumption that dark cyclotron photons have energies in visibleandUV range.

i. The value of integer n in $h_{eff} = n \times n$ equals to the ratio of gravitational and ordinary Compton lengths

$$n = \frac{h_{eff}}{h} = \frac{\lambda_{gr}}{\lambda_c} \quad .$$

For electron one obtains $n = .6 \times 10^{15}$. In the case of proton the frequency the ratio would be by a factor about 2×10^3 higher.

The value of n is much higher than the lower bound $10^9/6$ given as the ratio of visible photon frequency about 10^{14} Hz and cyclotron frequency $f = 6 \times 10^5$ Hz of electron in the magnetic field having the nominal value $B_{end} = .2$ Gauss of endogenous magnetic field. The discrepancy is six orders of magnitude. Desired value would be correspond to magnetic field strengths of order B_{end} in $B_{gal} = 1$ nT range which corresponds to the order of magnitude for galactic magnetic fields.

The value of n would give for B_{end} and an ion with 10 Hz cyclotron frequency (say Fe^{++} ion) energy of visible photon. The condition $\frac{h_{eff}}{h}$ predicts a value which is at least by a factor $m_p/m_e \simeq 2^{11}$ higher and one must also now assume galactic magnetic field strength to obtain a sensible result.

ii. The naïve expectation was that $B_{end} = .2 \times 10^{-4}$ Tesla should give energy in few eV range. Something goes definitely wrong since the magnetic fields in this value range should be in key role. Either the hypothesis $h_{eff} = h_{gr}$ is wrong or the model is somehow wrong.

iii. It is of course very naïve to assume that only single value of magnetic field is important. In fact, precognitve events are found to occur most frequently almost in the middle of sideral day which could be explained as being due to the involvement of galactic magnetic field.

6.1.3 Should one modify the $h_{gr} = h_{eff}$ hypothesis?

If one wants bio-photon spectrum to be in visible-UV range assuming that bio-photons correspond to cyclotron photons, one must reduce the value of $r = h_{gr}B_{end}/mv_0$ for Earth particle system by a factor of order $k = 2 \times 10^{-4}$. r does not depend on the mass of the charged particle. One can replace B_{end} with some other magnetic field having value which is considerably smaller. One can also increase the value of v_0.

i. For h_{gr} determined by Earth's mass and $v_0 = v_{rot}$, where $v_{rot} \simeq 1.55 \times 10^{-6}c$ is the rotation velocity of Earth around its axis and for $B_{end} \to B_{gal} = 1$ nT, where B_{gal} is typical strength of galactic magnetic field, the energy of dark cyclotron energy is 45 eV (UV extends to 124 eV). This is roughly by a factor 50 higher than the lower bound for the range of bio-photon energies. One possibility is that B_{gal} defines the upper limit of the dark photon energies and has variation range of at least 7 octaves with lower limit roughly 1/50 nT.

   One can also consider the possibility B_{gal} defines lower bound for the magnetic field strengths involved and one has $v_0 > v_{rot}$. For sun the rotation velocity at Equator is $v_{rot} = 2 \times 10^{-5}$ m/s and v_0 is $v_0 \simeq 5.8 \times 10^{-4}c$. One has $v_0/v_{rot} \simeq 29.0$. If same is true in case of Earth, the value of the energy comes down from 25 eV to 1.6 eV which corresponds to visible wave length.

   The assignment of B_{gal} to gravitational flux tubes is very natural. Now however the frequencies of dark variants of bio-photons would not be in EEG range: 10 Hz frequency would correspond to 5×10^{-4} Hz with period of 42 min. The time scale of 42 min is however very natural concerning consciousness and could be involved with longer bio-rhythms. Scaled EEG spectrum with alpha band around 46 min naturally assignable to diurnal sub-rhythms could be a testable prediction. Natural time would be sidereal (galactic) time with slightly different length of day and this allows a clear test. Recall the mysterious looking finding of Spottiswoode that precognition seems to be enhanced at certain time of sidereal day [J4]. Cyclotron frequency 1 Hz would correspond to 7 hours. One can ask whether 12 hours (25) is the natural counterpart for the cyclotron frequency 1 Hz assignable to DNA. This would correspond to lower bound $B_{gal} \to 7B_{gal}/12 \simeq .58$ nT or to $v_0 \to 1.7v_0$.

ii. The idea has been that it is dark EEG photons, which correspond to bio-photons. Could one assign bio-photons also to dark EEG so that magnetic fields of Earth and galaxy would correspond to two different control levels? If $B_{end} = .2$ Gauss is assumed to determine the scale of the magnetic field associated with the flux tubes carrying gravitational flux tubes, one must reduce h_{gr}. The reduction could be due to $M \to M_D = kM$ and due to the change of v_0. k could characterize the dark matter portion of Earth but this assumption is not necessary.

   This would require $k = M_{dark,E}/M_E \simeq 5 \times 10^{-5}$ if one does not change the value of v_0. This value of k equals to the ratio of B_{gal}/B_{end} and would be 1/4:th of $k = 2 \times 10^{-4}$. One might argue that it is indeed dark matter to which the gravitational flux tubes with large value of Planck constant connect biomatter.

iii. Suppose that one does not give up the idea that also Earth mass gives rise to h_{gr} and scaled analog of EEG. Then M_D must correspond to some mass distinguishable from and thus outside Earth. The simplest hypothesis is that a spherical layer around Earth is in question. TGD based model for spherical objects indeed predict layered structures [K50]. There are two separate anomalies in the solar system supporting the existence of a spherical layer consisting of dark mass and with radius equal to the distance of Moon from Earth equal to 60.3 Earth radii [K45]. The first anomaly is so called Flyby anomaly and second one involves a periodic variation of both the value of the measured Newton's constant at the surface of Earth and of the length of the day. The period is about 6 years and TGD predicts it correctly.

   One can imagine that dark particles reside at the flux tubes connecting diametrically opposite points of the spherical layer. Particles would experience the sum

of gravitational forces summing up to zero in the center of Earth. Although the layer would be almost invisible (or completely invisible by argument utilizing the analogy with conducting shell) gravitationally in its interior, $h_{gr} = M_D m/v_0$ would make itself visible in the dynamics of dark particles! This layer could represent magnetic Mother Gaia and EEG would take care of communications to this layer.

The rotation velocity $v_{rot,M} \simeq 2.1 \times v_{rot,E}$ of Moon around its axis is the first guess for the parameter v_0 identifiable perhaps as rotation velocity of the spherical layer. A better guess is that the ratio $r = v_0/v_{rot,M}$ is the same as for Sun and as assumed above for Earth. This would give for the ratio of cyclotron frequency scales $r = (B_{end}/B_{gal}) \times 2.1$. 66.7 min, which corresponds to $B_{gal} = .63$ nT, would correspond to .1 s. For this choice 1 Hz DNA cyclotron frequency would correspond 11.7 h rather near to 12 h. This encourages the hypothesis that 72 min is the counterpart of .1 s cyclotron time. The cyclotron time of DNA (very weakly dependent on the length of DNA double strand) in B_{gal} (or its minimum value) would be 12 h.

6.1.4 Did animal mitochondrial evolution have a long period of stagnation?

I encountered an interesting popular article (see `http://tinyurl.com/y9akruh`) telling about findings challenging Darwin's evolutionary theory. A technical representation can be found from the original article of Stoeckle and Thaler (see `http://tinyurl.com/ycsdc279`).

The conclusion of the article is that almost all animals, 9 out of 10 animal species on Earth today, including humans, would have emerged about 100,000 200,000 years ago. According to Wikipedia all animals are assumed to have emerged about 650 million years ago from a common ancestor. Cambrian explosion began around 542 million years ago and meant a sudden emergence of complex life forms. What happened looks like a mystery. TGD based explanation involving TGD based new physics is discussed [K20]. According to Wikipedia Homo Sapiens would have emerged 300,000-800,000 years ago.

On basis of Darwin's theory based on survival of the fittest and adaptation to a new environment, one would expect that the species such as ants and humans with large populations distributed around the globe become genetically more diverse over time than the species living in the same environment. The study of so called neutral mutations not relevant for survival and assumed to occur with some constant rate however finds that this is not the case. The study of so called mitochondrial DNA barcodes across 100,000 species showed that the variation of neutral mutations became very small about 100,000-200,000 years ago. One could say that the evolution differentiating between them began (or effectively began) after this time. As if mitochondrial clocks for these species would have been reset to zero at that time as the article states it. This is taken as a support for the conclusion that all animals emerged about the same time as humans.

The proposal of (at least) the writer of popular article is that the life was almost wiped out by a great catastrophe and extraterrestrials could have helped to start the new beginning. This brings in mind Noah's Ark scenario. But can one argue that humans and the other animals emerged at that time: were they only survivors from a catastrophe. One can also argue that the rate of mitochondrial mutations increased dramatically for some reason at that time.

Could one think that great evolutionary leap initiating the differentiation of mitochondrial genomes at that time and that before it the differentiation was very slow for some reason? Why this change would have occurred simultaneously in almost all animals? Something should have happened to the mitochondria and what kind of external evolutionary pressure could have caused it?

i. To me the idea about ETs performing large scale genetic engineering does not sound very convincing. That only a small fraction of animals survived the catastrophe sounds more plausible idea. Was it great flood? One can argue that animals living in water would have survived in this case. Could some cosmic event such as nearby

supernova have produced radiation killing most animals? But is mass extinction really necessary? Could some evolutionary pressure without extinction caused the apparent resetting of mitochondrial clock?

ii. In TGD based quantum biology the great leaps could be caused by quantum criticality perhaps induced by some evolutionary pressure due to some kind of catastrophe. The value of $h_{eff} = nh_0$ (h_0 is the minimal value of Planck constant) - kind of IQ in very general sense - in some part of mitochondria could have increased and also its value would have fluctuated. Did a new longer length scale relevant to the functioning of mitochondrias emerge? Did the mitochondrial size increase? Here I meet the boundaries of my knowledge about evolutionary biology!

iii. Forget for a moment the possibility of mass extinction. Could the rate of mutations, in particular the rate of neutral mutations, have increased as a response to evolutionary pressure? Just the increased ability to change helps to survive. This rate would become high at quantum criticality due to the presence of large quantum fluctuations (variations of h_{eff}). If the mitochondria were far from quantum quantum criticality before the catastrophe, the rate of mutations would have been very slow. Animal kingdom would have lived a period of stagnation. The emerging quantum criticality - forced by a catastrophe but not involving an extinction - could have increased the rate dramatically. This picture would provide formulation for the notion of punctuated equilibria in terms of quantum criticality.

6.1.5 An island at which body size shrinks

I encountered in Facebook an article claiming that the bodies of animals shrink at the island of Flores belonging to Indonesia (see `http://tinyurl.com/ycluutnql`). This news is not Dog's days news (Dog's days news is a direct translation from the finnish synonym for fake news).

Both animals and humans really are claimed to have shrinked in size. The bodies of both hominins (precedessors of humans, humans, ane even elephants) have shrinked at Flores.

i. In 2003, researchers discovered in a mountain cave in the island of Flores fossils of tiny, humanlike individual. It had chimp sized brain and was 90 cm tall. Several villages at the area are inhabited by people with average body height about 1.45 meters.

ii. Could the small size of the recent humans at Flores be due to interbreeding between modern humans with Homo Florensiensis (HF) occurred long time ago? The hypothesis could be tested by studying the DNA of HF. Since the estimate age of fossils of HF was 10,000 years, researchers hoped that they could find some DNA to HF. DNA was not found but researchers realized that if HF as interbreeded with humans, this DNA could show itself in DNA of modern humans at Flores. It was found that this DNA can be identified but differs insignificantly from that of modern humans. It was also found that the age of the fossils was about 60,000 years.

iii. Therefore it seems that the interbreeding did not cause the reduction in size. The study also showed that at least twice in the ancient history of humans and their relatives arrived as Flores and then grew shorter [I12] (see `http://tinyurl.com/y9th5zne`). This happened also for elephants that arrived to Flores at twice.

This looks really weird! Weirdness in this proportion allows some totally irresponsible speculation.

i. The hierarchy of Planck constants $h_{eff} = nh_0$ ($h = 6h_0$ is a good guess [L15, L32, L12]) assigned with dark matter as phases of ordinary matter and responsible for macroscopic quantum coherence is central in TGD inspired biology. Quantum scales are proportional to or its power (h_{eff}^2 for atoms, h_{eff} for Compton length, and $h_{eff}^{1/2}$ for cyclotron states).

ii. The value of gravitational Planck constant h_{gr} (= h_{eff}) at the flux tubes mediating gravitational interaction could determine the size scale of the animals. Could one consider a local anomaly in which the value of h_{gr} is reduced and leads to a shrinkage of also body size?

iii. h_{gr} is of form $\hbar_{gr} = GM_Dm/v_0$, where v_0 a velocity parameter [**?**, K37] [L31] (see `http://tinyurl.com/y8xhvwt2`, `http://tinyurl.com/yaattlzm`, and `http://tinyurl.com/y8vnyppq`). M_D is a large dark mass of order 10^{-4} times the mass of Earth. Gravitational Compton length $\Lambda_{gr} = h_{gr}/m = GM_D/v_0$ for a particle with mass m. $\Lambda_{gr} = h_{gr}/m$ does not depend on the mass of the particle - this conforms with Equivalence Principle. The estimate of [L31] gives $\Lambda_{gr} = 2\pi GM_D/v_0 = 2.9 \times r_S(E)$, where the Schwartshild radius of Earth is $r_S(E) = 2GM_E = .9$ mm. This gives $\Lambda_{gr} = 2.6$ mm, which corresponds to p-adic length scale $L(k = 187)$. Brain contains neuron blobs with this size scale. The size scale of organism is expected to be some not too large multiple of this scale.

Could one think that v_0 at Flores is larger than normally and reduces the value of Λ_{gr} so that the size for the gravitational part of the magnetic body of any organism shrinks, and that this gradually leads to a reduction of the size of the biological body. Second possibility is that the value of dark mass M_D is at Flores smaller than elsewhere: one would have a dark analogy of ordinary local gravitational anomaly. The reduction of h_{gr} should be rather large so that the first option looks more plausible.

6.2 Why metabolism and what happens in bio-catalysis?

TGD view about dark matter gives also a strong grasp to metabolism and bio-catalysis - the key elements of biology.

6.2.1 Why metabolic energy is needed?

The simplest and at the same time most difficult question that innocent student can make about biology class is simple: "Why we must eat?". Or using more physics oriented language: "Why we must get metabolic energy?". The answer of the teacher might be that we do not eat to get energy but to get order. The stuff that we eat contains ordered energy: we eat order. But order in standard physics is lack of entropy, lack of disorder. Student could get nosy and argue that excretion produces the same outcome as eating but is not enough to survive.

We could go to a deeper level and ask why metabolic energy is needed in biochemistry. Suppose we do this in TGD Universe with dark matter identified as phases characterized by $h_{eff}/h = n$.

i. Why metabolic energy would be needed? Intuitive answer is that evolution requires it and that evolution corresponds to the increase of $n = h_{eff}/h$. To see the answer to the question, notice that the energy scale for the bound states of an atom is proportional to $1/h^2$ and for dark atom to $1/h_{eff}^2 \propto n^2$ (do not confuse this n with the integer n labelling the states of hydrogen atom!).

ii. Dark atoms have smaller binding energies and their creation by a phase transition increasing the value of n demands a feed of energy - metabolic energy! If the metabolic energy feed stops, n is gradually reduced. System gets tired, loses consciousness, and eventually dies.

What is remarkable that the scale of atomic binding energies decreases with n only in dimension $D = 3$. In other dimensions it increases and in $D = 4$ one cannot even speak of bound states! This can be easily found by a study of Schrödinger equation for the analog of hydrogen atom in various dimensions. Life based on metabolism seems to make sense only in spatial dimension $D = 3$. Note however that there are also other quantum states than atomic states with different dependence of energy on h_{eff}.

6.2.2 Conditions on bio-catalysis

Bio-catalysis is key mechanism of biology and its extreme efficacy remains to be understood. Enzymes are proteins and ribozymes RNA sequences acting as biocatalysts.

What catalysis demands?

i. Catalyst and reactants must find each other. How this could happen is very difficult to understand in standard biochemistry in which living matter is seen as soup of biomolecules. I have already already considered the mechanisms making it possible for the reactants to find each other. For instance, in the translation of mRNA to protein tRNA molecules must find their way to mRNA at ribosome. The proposal is that reconnection allowing U-shaped magnetic flux tubes to reconnect to a pair of flux tube connecting mRNA and tRNA molecule and reduction of the value of $h_{eff} = n \times h$ inducing reduction of the length of magnetic flux tube takes care of this step. This applies also to DNA transcription and DNA replication and bio-chemical reactions in general.

ii. Catalyst must provide energy for the reactants (their number is typically two) to overcome the potential wall making the reaction rate very slow for energies around thermal energy. The TGD based model for the hydrino atom having larger binding energy than hydrogen atom claimed by Randell Mills [D11] suggests a solution [L15]. Some hydrogen atom in catalyst goes from (dark) hydrogen atom state to hydrino state (state with smaller h_{eff}/h and liberates the excess binding energy kicking the either reactant over the potential wall so that reaction can process. After the reaction the catalyst returns to the normal state and absorbs the binding energy.

iii. In the reaction volume catalyst and reactants must be guided to correct places. The simplest model of catalysis relies on lock-and-key mechanism. The generalized Chladni mechanism forcing the reactants to a two-dimensional closed nodal surface is a natural candidate to consider. There are also additional conditions. For instance, the reactants must have correct orientation. For instance, the reactants must have correct orientation and this could be forced by the interaction with the em field of ME involved with Chladni mechanism.

iv. One must have also a coherence of chemical reactions meaning that the reaction can occur in a large volume - say in different cell interiors - simultaneously. Here MB would induce the coherence by using MEs. Chladni mechanism might explain this if there is there is interference of forces caused by periodic standing waves themselves represented as pairs of MEs.

6.2.3 Phase transition reducing the value of $h_{eff}/h = n$ as a basic step in bio-catalysis

Hydrogen atom allows also large $h_{eff}/h = n$ variants with $n > 6$ with the scale of energy spectrum behaving as $(6/n)^2$ if the $n = 4$ holds true for visible matter. The reduction of n as the flux tube contracts would reduce n and liberate binding energy, which could be used to promote the catalysis.

The notion of high energy phosphate bond is somewhat mysterious concept and manifests as the ability provide energy in ATP to ADP transition. There are claims that there is no such bond. I have spent considerable amount of time to ponder this problem. Could phosphate contain (dark) hydrogen atom able to go to the a state with a smaller value of h_{eff}/h¡ and liberate the excess binding energy? Could the phosphorylation of acceptor molecule transfer this dark atom associated with the phosphate of ATP to the acceptor molecule? Could the mysterious high energy phosphate bond correspond to the dark atom state. Metabolic energy would be needed to transform ADP to ATP and would generate dark atom.

Could solar light kick atoms into dark states and in this manner store metabolic energy? Could nutrients carry these dark atoms? Could this energy be liberated as the dark

atoms return to ordinary states and be used to drive protons against potential gradient through ATP synthase analogous to a turbine of a power plant transforming ADP to ATP and reproducing the dark atom and thus the "high energy phosphate bond" in ATP? Can one see metabolism as transfer of dark atoms? Could possible negentropic entanglement disappear and emerge again after ADP→ ATP.

Here it is essential that the energies of the hydrogen atom depend on $\hbar_{eff} = n \times h$ in as $\hbar_{eff}^m$, $m = -2 < 0$. Hydrogen atoms in dimension D have Coulomb potential behaving as $1/r^{D-2}$ from Gauss law and the Schrödinger equation predicts for $D \neq 4$ that the energies satisfy $E_n \propto (h_{eff}/h)^m$, $m = 2 + 4/(D-4)$. For $D = 4$ the formula breaks since in this case the dependence on $\hbar$ is not given by power law. m is negative only for $D = 3$ and one has $m = -2$. There $D = 3$ would be unique dimension in allowing the hydrino-like states making possible bio-catalysis and life in the proposed scenario.

It is also essential that the flux tubes are radial flux tubes in the Coulomb field of charged particle. This makes sense in many-sheeted space-time: electrons would be associated with a pair formed by flux tube and 3-D atom so that only part of electric flux would interact with the electron touching both space-time sheets. This would give the analog of Schrödinger equation in Coulomb potential restricted to the interior of the flux tube. The dimensional analysis for the 1-D Schrödinger equation with Coulomb potential would give also in this case $1/n^2$ dependence. Same applies to states localized to 2-D sheets with charged ion in the center. This kind of states bring in mind Rydberg states of ordinary atom with large value of n.

The condition that the dark binding energy is above the thermal energy gives a condition on the value of $h_{eff}/h = n$ as $n \leq 32$. The size scale of the dark largest allowed dark atom would be about 100 nm, 10 times the thickness of the cell membrane.

6.2.4 How molecules in cells "find" one another and organize into structures?

The title of the popular article "How molecules in cells 'find' one another and organize into structures?" (see `http://tinyurl.com/ydbznknn`) expresses an old problem of biology. Now the group led by Amy S. Gladfelter has made experimental progress in this problem. The work has been published in Science [I11] (see `http://tinyurl.com/ybwyugho`).

It is reported that RNA molecules recognize each other to condense into the same droplet due to the specific 3D shapes that the molecules assume. Molecules with complementary base pairing can find each other and only similar RNAs condense on same droplet. This brings in mind DNA replication, transcription and translation. Furthermore, the same proteins that form liquid droplets in healthy cells, solidify in diseases like neurodegenerative disorders.

Some kind of phase transition is involved with the process but what brings the molecules together remains still a mystery. The TGD based solution of this mystery is one of the first applications of the notion of many-sheeted space-time in biology, and relies on the notion of magnetic flux tubes connecting molecules to form networks.

Consider first the TGD based model about condensed and living matter. As a matter fact, the core of this model applies in all scales. What is new is there are not only particles but also bonds connecting them. In TGD they are flux tubes which can carry dark particles with nonstandard value $h_{eff}/h = n$ of Planck constant. In ER-EPR approach in fashion they would be wormholes connecting distance space-time regions. In this case the problem is instability: wormholes pinch and split. In TGD monopole magnetic flux takes care of the stability topologically.

The flux tube networks occur in all scales but especially important are biological length scales.

i. In chemistry the flux tubes are associated with valence bonds and hydrogen bonds [L23] (see `http://tinyurl.com/ycg94xpl`). In biology genetic code would be realized as dark nuclei formed by sequences of dark protons at magnetic flux tubes.

Also RNA, amino-acids, and even tRNA could have dark counterparts of this kind [L11] (see http://tinyurl.com/jgfjlbe). Dark variants of biomolecules would serve as templates for their ordinary variants also at the level of dynamics. Biochemistry would be shadow dynamics dictated to high degree by the dark matter at flux tubes.

ii. Dark valence bonds can have quite long length and the outcome is entangled tensor net [L21](see http://tinyurl.com/y9kwnqfa). These neuronal nets serve as correlates for cognitive mental images in brain (see http://tinyurl.com/yczv2o5b) emotional mental images in body [L34] (see http://tinyurl.com/ydhxen4g). Dark photons propagating along flux tubes (more precisely topological light rays parallel to them) would be the fundamental communication mechanism [K7] (see http://tinyurl.com/ydx9dq6x). Transmitters and nerve pulses would only change the connectedness properties of these nets.

The topological dynamics of flux tubes has two basic mechanisms (I have discussed this dynamics from the point of view of AI [L19] (see http://tinyurl.com/y75246rk).

i. Reconnection of flux tubes serves is the first basic mechanism in the dynamics of flux tube networks and would give among other things rise to neural nets. The connection between neurons would correspond basically to flux tube pair which can split by reconnection. Also two flux tube pairs can reconnect forming Y shaped structures. Flux tube pairs could be quite generally associated with long dark hydrogen bonds scaled up by $h_{eff}/h = n$ from their ordinary lengths. Flux tube pairs would carry besides dark protons also supra phases formed by the lone electron pairs associated quite generally with hydrogen bonding atoms. Also dark ions could appear at flux tubes.

   Biomolecules would have flux loops continually scanning the environment and reconnecting if they meet another flux loop. This however requires that magnetic field strengths are same at the two loops so that a resonance is achieved at level of dark photon communications. This makes possible recognition by cyclotron frequency spectrum serving as signature of the magnetic body of the molecule.

   Water memory [K9] (see http://tinyurl.com/ycqy837a) would rely on this recognition mechanism based on cyclotron frequencies and also immune system would use it at basic level (here one cannot avoid saying something about homeopathy although I know that this spoils the day of the skeptic: the same mechanism would be involved also with it). For instance, dark DNA strand accompanying ordinary DNA and dark RNA molecules find each other by this mechanism (see http://tinyurl.com/yalny39x). Same applies to other reactions such as replication and translation .

ii. Shortening of the flux tubes h_{eff}/h reducing phase transition is second basic mechanism explaining how biomolecules can find each other in dense molecular soup. It is essential that the magnetic fields at flux tubes are nearly the same for the reconnection to form. A more refined model for the shortening involves two steps: reconnection of flux tubes leading to a formation of flux tube pair between molecules and shortening by h_{eff}/h reducing phase transition.

Also ordinary condensed matter phase transitions involve change of the topology of flux tube networks and the model for it allows to put the findings described in the article in TGD perspective.

i. Quite recently I wrote an article [L36] (see http://tinyurl.com/ydhknc2c) about a solution of two old problems of hydrothermodynamics: the behavior of liquid-gas system in the critical region not consistent with the predictions of statistical mechanics (known already at times of Maxwell!) and the behavior of water above freezing point and in freezing. Dark flux tubes carrying dark protons and possibly electronic Cooper pairs made from so called lone electron pairs characterizing atoms forming hydrogen bonds.

ii. The phase transition from gas to liquid occurs when the number of flux tubes per molecule is high enough. At criticality both phases are in mechanical equilibrium - same pressure. Most interestingly, in solidification the large h_{eff} flux tubes transform to ordinary ones and liberate energy: this explains anomalously high latent heats of water and ammonia. The loss of large h_{eff} flux tubes however reduces "IQ" of the system.

The phase transitions changing the connectedness of the flux tube networks are fundamental in TGD inspired quantum biology.

i. Sol-gel transition would correspond to this kind of biological phase transitions. Protein folding [K3] (see `http://tinyurl.com/y9lqmtea`) - kind of freezing of protein making it biologically inactive - and unfolding would be second basic example of this transition. The freezing would involve formation of flux tube bonds between points of linear protein and assignable to hydrogen bonds. External perturbations induce melting of the proteins and they become biologically active as the value of $h_{eff}/h = n$ characterizing their maximal possible entanglement negentropy content (molecular IQ) increases. External perturbation feeds in energy acting as metabolic energy. I have called this period molecular summer.

ii. Solidification of proteins reducing is reported to be associated with diseases such neurodegenerative disorders. In TGD picture this would reduce the molecular IQ since the ability of system to generate negentropy would be reduced when $h_{eff}$for the flux tubes decreases to its ordinary value. What brings molecules together is not understood and TGD provides the explanation as h_{eff} reducing phase transition for flux tube pairs.

The evidence for the hierarchy of Planck constants $h_{eff}/h = n$ labelling dark matter as phases with non-standard value of Planck constant [**?**] is accumulating. The latest piece of evidence for the hierarchy of Planck constants comes from the well-known mystery (not to me until now!) related to rare Earth metals. Some valence electrons of these atoms mystically "disappear" when the atom is heated. This transition is known as Lifshitz transition. The popular article "*Where did those electrons go? Decades-old mystery solved*" (see`http://tinyurl.com/ychzjg8d`) claims that the mystery of disappearing valence electrons is finally resolved. The popular article is inspired by the article "*Lifshitz transition from valence fluctuations in YbAl3*" by Chatterjee *et al* published in Nature Communications [L26] (see `http://tinyurl.com/ybejzq87`).

The finding [D9] (see `http://tinyurl.com/ybntawq4`) about misbehaving Ruthenium atoms supports the view that covalent bonds involve dark valence electrons. Pairs of Ru atoms were expected to transform to Ru dimers in thermodynamical equilibrium but this did not happen. This suggests that valence electrons associated with the valence bond of Ru dimers are dark in TGD sense and the valence bonded Ru dimer has a higher energy than a pair of free Ru atoms. The alternative option is that darkness makes the decay of Ru pairs to Ru dimers with smaller energy very slow.

6.2.5 Are mysteriously disappearing electrons dark in TGD sense?

The mysterious disappearance of valence electrons brings in mind dark atoms with Planck constant $h_{eff} = n \times h$. Dark matter corresponds in TGD Universe to a hierarchy with levels labelled by the value of h_{eff}. One prediction is that the binding energy of dark atom is proportional to $1/h_{eff}^2$ and thus behaves like $1/n^2$ and decreases with n.

$n = 1$ is the first guess for ordinary atoms but just a guess. The claim of Randell Mills is that hydrogen has exotic ground states with larger binding energy. A closer examination suggests $n = n_0 = 6$ for ordinary states of atoms. The exotic states would have $n < 6$ and therefore higher binding energy scale [L15, L24] (see `http://tinyurl.com/goruuzm` and `http://tinyurl.com/y7sc98lz`).

This leads to a model of biocatalysis in which reacting molecules contain dark hydrogen atoms with non-standard value of n larger than usual so that their binding energy is

lower. When dark atom or electron becomes ordinary binding energy is liberated and can kick molecules over the potential wall otherwise preventing the reaction to occur. After that the energy is returned and the atom becomes dark again. Dark atoms would be catalytic switches. Metabolic energy feed would take care of creating the dark states. In fact, $h_{eff}/h = n$ serves as a kind of intelligence quotient for a system in TGD inspired theory of consciousness.

Could the heating of the rare earth atoms transform some valence electrons to dark electrons with $h_{eff}/h = n$ larger than for ordinary atom? The natural guess is that thermal energy kicks the valence electron to a dark orbital with a smaller binding energy? The prediction is that there should be critical temperatures behaving like $T_{cr} = T_0(1 - n_0^2/n^2)$. Also transitions between different dark states are possible. These transitions might be also induced by irradiating the atom with photons with the transition energy between different dark states having same quantum numbers.

This picture leads to a new formulation of valence bond theory. The lengths of molecular bonds vary in rather narrow range whereas Schrödinger equation suggests that the bond lengths r should scale as $r \propto m^2/Z^2$ for $n = 1$ (m labels the rows of the periodic table). Closed shell electrons screen Z to $Z_{eff} = n_V$, n_V the number of valence electrons so that the formula $e = n^2m^2/Z_{eff}^2$ is a more natural starting point, and conforms with the basic idea about periodic system. This leads to a model allowing to estimate the value of n for given bond allowing also qualitative picture about electro-negativities of valence bonds. Also a comparison with bio-chemistry becomes possible. Hydrogen bond can be understood in terms of de-localization of proton.

6.2.6 About possible implications

The proposed explanation of the disappearing valence electrons allows to sharpen the hypothesis for dark ions. Actually dark atoms with some dark valence electrons would be in question.

1. ORMEs as one manner to end up with $h_{eff}/h = n$ hypothesis

I ended up to the discovery of dark matter hierarchy and eventually to adelic physics [L28], where $h_{eff}/h = n$ has number theoretic interpretation along several roads starting from anomalous findings. One of these roads began from the claim about the existence of strange form of matter by David Hudson. Hudson associated with these strange materials several names: White Gold, monoatomic elements, and ORMEs (orbitally re-arranged metallic elements). Any colleague without suicidical tendencies would of course refuse to touch anything like White Gold even with a 10 meter long pole but I had nothing to lose anymore.

My question was how to explain these elements if they are actually real [K10, K18]. If all valence electrons of this kind of element are dark these element have effectively full electron shells as far as ordinary electrons are considered and behave like noble gases with charge in short scales and do not form molecules. Therefore "monoatomic element" is justified. Of course, only the electrons in the outermost shell could be dark and in this case the element would behave chemically and also look like an atom with smaller atomic number Z. So called Rydberg atoms for which valence electrons are believed to reside at very large orbitals could be actually dark atoms in the proposed sense.

Obviously also ORME is an appropriate term since some valence electrons have re-arranged orbitally. White Gold would be Gold but with dark valence electron. The electron configuration of Gold is $[Xe]4f^{14}5d^{10}6s^1$. There is single unpaired electron with principal quantum number $m = 6$ and this would be dark for White Gold and chemically like Platinum (Pt), which indeed has white color.

2. Biologically important ions as analogs of ORMEs?

In TGD inspired biology the biologically important atoms H^+, Li^+, Na^+, K^+, Ca^{++}, Mg^{++} are assumed to be dark in the proposed sense. But I have not specified darkness in precise sense. Could these ions have dark valence electrons with scaled up Compton

length and forming macroscopic quantum phases. For instance, Cooper pairs could become possible and make possible high Tc superconductivity with members of Cooper pair at parallel flux tubes. The earlier proposal that dark hydrogen atoms make possible biocatalysis becomes more detailed: at higher evolutionary levels also the heavier dark atoms behaving like noble gases would become important in bio-catalysis. Interestingly, Rydberg atoms have been proposed to be important for biology and they could be actually dark atoms [L9].

To sum up, if TGD view is correct, an entire spectroscopy of dark atoms and partially dark molecules is waiting to be discovered and irradiation by light with energies corresponding to excitation energies of dark states could be the manner to generate dark atomic matter. Huge progress in quantum biology could also take place. But are colleagues mature enough to check whether the TGD view is correct?

6.2.7 Misbehaving Ruthenium atoms

In Facebook I received a link to a highly interesting article (see `http://tinyurl.com/ybntawq4`) with title "*Breakthrough could launch organic electronics beyond cell phone screens*" tailored to catch the attention of techno-oriented leader. My attention was however caught for different reasons. The proposed technology would rely on the observation that Ruthenium atoms do not behave as they are expected to behave.

Ru atoms appear as dimers of two Ru atoms in the system considered. Free Ru atoms with one valence electron are however needed: they would become ions by giving up their valence electrons, and these electrons would serve as current carriers making the organic material in question semi-conductor. Irradiation by UV light was found to split Ruthenium dimers to single Ru atoms. If the total energy of Ru dimer is smaller than that for two Ru atoms, thermodynamics predicts that the Ru atoms recombine to dimers after the irradiation ceases. The did not however happen!

Can one understand the mystery in TGD framework?

i. Ru atoms have one outer s-electron at 5:th shell. One would expect that Ru dimer has valence bond with shared 5s electrons. I recently learned about mysteriously disappearing valence electrons of rare Earth metals caused by heating [L26]) (see `http://tinyurl.com/y7cxs8uz`). This gives strong support for the idea that valence electrons of free atoms can become dark in TGD sense: that is their Planck constant increases and the orbitals become large. The analogy with Rydberg atoms is obvious and it could be that Rydberg atoms in some case have dark valence electrons. Since electron's binding energy scale scales like $1/h_{eff}^2$ $h_{eff}/h = n \times h$, the creation of these states requires energy and therefore heating is required. Also irradiation by photons with energy equal to energy difference between ordinary and dark states should give rise to the same phenomenon. This would provide a way to create dark electrons and a new technology.

ii. This also inspired the proposal that valence bond (thought to be understood in chemistry with inspiration coming from the reductionistic dogma) involves flux tube pair and $h_{eff}/h = n$ which is larger than for ordinary quantum theory. This provides new very concrete support for the view that thetransitions from atomic physics to chemistry and from chemistry to organic chemistry could involve new physics provided by TGD [L30] (see `http://tinyurl.com/yaq3459e`).

   The step from atomic physics to chemistry with valence bond would involve new physics: the delocalization of valence electrons to flux tubes due to the increase of h_{eff}! Valence electrons would be dark matter in TGD sense! The step from chemistry to organic chemistry would involve delocalization of proton as dark proton by similar mechanism and give rise to hydrogen bond and also many other new phenomena.

iii. The increase of h_{eff} would reduce the binding energy from the expected. This would be the case for so called (and somewhat mysterious) high energy phosphate

bond. This picture conforms with the fact that biological energy storage indeed relies on valence bonds.

If this vision is correct, the breaking of valence bond would split the flux tube pair between two Ru atoms by reconnection to flux loops associated with Ru atom. The resulting pair of free Ru atoms would have lower energy than Ru dimer and would be favored by thermodynamics. The paradox would disappear.

A couple of critical questions are in order.

i. Why irradiation would be needed at all? Irradiation would kick the dimer system over a potential wall separating it from a state two free Ru atoms. Also the magnetic energy of the flux tube would contribute to the energy of dimer and make it higher than that of free state.

ii. Why Ru dimers would not decay spontanously to pairs of free Ru atoms? This is the case if the energy needed to overcome the potential wall is higher than thermal energy at temperatures considered. One could also argue that electronic states with different values of $h_{eff}/h = n$ are not in thermal equilibrium: one has far-from-equilibrium thermodynamical state. These electrons would represent dark matter in TGD sense and interact rather weakly with ordinary matter so that it would take time for thermal equilibrium to establish itself.

TGD indeed leads to the proposal that the formation of states regarded as far-from-thermal equilibrium states in standard physics approach means formation of flux tubes networks with $h_{eff}/h = n$ larger than for the original state [L25] (see `http://tinyurl.com/yamdwop9` and `http://tinyurl.com/y8f95b5z`). If this interpretation is correct, then one can also consider the possibility that the energy of the free state is higher than that of the dimer as assumed by the experimenters.

6.3 Does valence bond theory relate to the hierarchy of Planck constants?

The idea that valence bonds, or at least some of them, correspond to non-standard value of $h_{eff}/h = n$ [L25] is very attractive. It could allow to understand what chemical bonds really are and allow a detailed view about how reductionism fails in the sequence of transitions from atomic physics to molecular physics to chemistry to biochemistry.

i. The standard value of n, call it n_{min} need not correspond to $n_{min} = 1$ and the findings of Randell Mills [D11] [L15] suggesting that hydrogen atom and possibly also other atoms can have binding energies coming as k^2 multiples of ordinary ones with $k = 2, 3, 6$, suggests that $n_{min} = 6$ could correspond to the standard value of h_{eff} for atoms. $n > n_{min}$ would mean reduced binding energy and this would mean the possibility of high energy valence bonds.

ii. The binding energy of atom would scale as $1/n^2$ so that for non-standard values of $n > n_{min}$ would correspond to smaller binding energy scale. The finding that heating of rare-earth atoms leads to a disappearance of some valence electrons [L26] suggests that the value of n for some valence electrons increases from n_{min} in these situation. The same effect might be achieved by irradiation at suitable photon energies corresponding to energy difference between ordinary state and dark state of electrons. An entire spectroscopy of atoms with dark valence electrons would be waiting to be discovered.

iii. $n > n_{min}$ would explain why valence bonds are carriers of metabolic energy liberated in catabolic part of metabolism. The temporary reduction of of n would induce a temporary localication by shortening of flux tubes and in turn make possible bio-catalysis by kicking the reactants over the potential wall making the reaction slow. The shortening of long flux tube bonds between reacts as the value of n is reduced could explain why bio-molecules are able to find each other in the molecular crowd.

iv. The Bohr radii of valence electrons of atoms scale as $a_B \propto m^2/Z_{eff}^2$, where m (usually denoted by n) is the principal quantum number determining the value of energy in the model based on Schrödinger equation. Z_{eff} is in good approximation equal to the unscreened nuclear charge $Z_{eff} = n_V$ equal to the number of valence electrons. If the superposition of atomic orbitals restricted to valence bonds is the essence in the formation of molecules, one an argue that the lengths of bonds and radii of molecules should decrease rapidly with Z_{eff}. However, the empirical fact is that the bond lengths vary in a rather narrow range, roughly by factor 2!

The solution of the problem looks rather unique.

i. The value of n assignable to the valence bond is scaled so that nm/Z_{eff} is near to unity so that the Bohr radius is near to that for hydrogen atom. Z_{eff} is naturally the charge unscreened by the closed electron shells and equal to the number $Z_{eff} = n_V$ of valence electrons. This conforms with the periodicity of the periodic table. Since the value of n is same for both bonded atoms, the value of Bohr radii differ which implies that electronic charge is shifted towards the atom with larger n_V and electro-negativities of atoms parameterizing this behavior are different for the atoms of the bond. This conforms qualitatively with the valence bond theory.

   For $n > n_{min}$ one would have $a_B \propto (n^2/n_{min})^2 m^2/Z_{eff}^2$, and if $nm/(n_{min}Z_{eff})$ is constant in reasonable approximation, the estimate for bond length does not depend much on Z. Could the weak variation of bond lengths be a direct indication that the reduction of molecular physics to atomic physics fails? Also the size of atoms in lattice about $2a_B(H)$ (one Angström) depends only weakly on Z_{eff}: could the constancy of $nm/(n_{min}Z_{eff})$ be true in reasonable approximation also for lattice bonds?

ii. The predicted lengths of valence bonds should be realistic: this forces $n > n_H$ and $n \propto Z_{eff}$ is a rough guess. One should also understand the values of electronegativities $\chi(X)$ allowing quantitative understanding about the distribution of charge along the bond. The bond lengths assignable to the bonded atoms are in general different and the one one with shorter bond length for electrons is expected to be more electronegative since the electrons for it are less de-localized.

6.3.1 Transition from atomic physics to molecular physics and chemistry

The transitions from atomic physics to chemistry and from chemistry to organic and biochemistries are poorly understood and the reductionistic dogma remain a mere belief. Could the valence bonds associated with magnetic flux tubes in TGD Universe and correspond to a non-standard value of n scaling up the value of Bohr radius by n^2? Could valence electron pairs form analogs of Cooper pairs with the length of bond defining the size scale of the Cooper pair. This could happen in aromatic cycles playing crucial role in molecular biology. Could various high energy valence bonds making possible the storage of metabolic energy correspond to valence bonds with $n > n_{min}$ possessing therefore smaller binding energy.

One has several options.

i. U-shaped flux tube are along single space-time sheet. U-shape would minimize magnetic energy.

ii. One could have closed flux tube going along first space-time sheet A, going to second sheet B through extremely short wormhole contact of size of order CP_2 radius, and returning back along B and back to A through wormhole contact. One would have a pair of flux tubes with opposite values of magnetic fields on top of each other in CP_2 direction. The net magnetic field experienced by a charged particle at QFT limit would vanish: I have called this structure wormhole magnetic field. For wormhole magnetic field the average magnetic field determining the magnetic field at QFT-GRT limit of TGD would vanish in good approximation.

iii. One could have single flux tube at sheet A going to B through wormhole contact and returning back along different route along B and returning back through wormhole contact. For a network of flux tubes one could have closed magnetic paths. In this case, charged particles would experience the magnetic field of only single flux tube. This option looks very attractive and one could realize Cooper pairs having members at different space-time sheets. The flux could be also monopole flux possible in TGD Universe thanks to the homology of CP_2.

First and third option look natural in the chemistry of valence bond. The prediction would be that valence electrons are de-localized along these bonds. If the wave function behaves like hydrogen atom wave function it decays exponentially with distance from each atom and a superposition of orbitals would be in question. The Bohr radius would be proportional to n^2 implying longer de-localization scale.

For hydrogen bonds proton would be de-localized as dark proton. This could represent transition from inorganic chemistry to organic chemistry. In TGD inspired quantum biology also other ions can be de-localized at magnetic flux tubes and these de-localizations represent a further steps away from atomic physics.

In biology n would serve as a kind of IQ for a system: understanding why this should be the case requires adelic physics serving as fusion of ordinary physics and physics of cognition represented by p-adic physics [L29] [L28]. The larger the value of n, the larger the maximal value of p-adic counterpart of entanglement negentropy, which is an analog of Shannon entropy but with algebraic number valued probability P appearing in $log(P)$ replaced by its p-adic norm $|P|_p$ for a suitable algebraic extension of rationals. This entropy can be negative and has in this case interpretation as information. The sum of real and p-adic entropies tends to be negative and has interpretation as a measure for conscious information.

6.3.2 Valence bond theory very briefly

How to test this hypothesis about valence bonds? Electronegativity and oxidation/reduction serve as the basic notions in valence bond theory (see `http://tinyurl.com/y8wyd9zm`). Valence rule tells which bonds are favored. Bond lengths and electro-negativities are basic parameters characterizing bonds. Can one interpret these notions in terms of $n = h_{eff}/h$ hierarchy of dark matters?

i. For atom, call it A, bonded to atoms B, C,.. the sum of valences of B, C,.. is the negative of the valence of A. For H-Cl and Na-Cl the valences are +1 and -1. C as valence 4 (or equivalently -4) and CH_4 represents example of this compensation. For O_2= O=O one as double valence bond.

ii. Bond length is the first key parameter allowing to get idea about valence bond. The table of Wikipedia article about the notion of bond length gives the bond lengths of C with other elements (see `http://tinyurl.com/ya4md73c`). Interestingly, C-H, C-C, C-O, C-N, C-S, C-Se bond lengths vary, which might have interpretation in terms of varying value of n: all bonds are important in biology. An alternative explanation for the variation would be that there are also other atoms involved.

The range of variation is [106, 112] pm for C-H; [120, 154] pm for C-C (the upper limit is achieved for diamond but even longer bond lengths are known), [147, 270] pm for C-N , [143, 215] pm for C-O (note that bond length for C-O-H is thus longer than for C-H), and [181, 255] pm for C-S.

Average bond lengths tend to decrease along the row of the periodic table and increase along column. The C-X bonds in hydrocarbons (alkenes, alkynes) are shorter than in organic polymers in general, which supports the view that they have as organic but non-living materia lower value of n than organic compounds in living matter. The bond lengths for C-metal bonds are rather long, for instance for C-Mg bond length is 207 pm, roughly twice C-H bond length.

iii. Electronegativity χ is second key parameter and allows a quantitative description of valence bonds. The rule is that the electrons of an atom with smaller electronegativity χ , call it A, tend to be nearer to those of the atom B with higher value of χ: one says that B oxidizes A and B is reduced. Both oxidation and reduction occur always and one talks about redox reactions, which are fundamental in biology. The term oxidation follows from the fact that oxygen O_2 is the best known oxidant.

The values of electronegativity for various elements are listed in Wikipedia article (see `http://tinyurl.com/pbh6r6c`) and give a rough idea about what happens for the valence electrons in various bonds. The reduction to two-atom level is only an approximation since the presence of other atoms modifies χ. For instance, the electro-negativities of C for C=O and C-(O-H) are different.

For instance, one has $\chi(X) \in \{2.20, .98, .93, 1.00\}$ for $X \in \{H, Li, Na, Ca\}$ with $(m, Z) \in$
$\{(1, 1), (2, 7), (3, 11), (4, 20)\}$. Clearly, one has $\chi(H) \sim 2\chi(X)$.

A naïve expectation is that the atom with the smaller value of n/Z is more electronegative (note that valence rule must be satisfied). Indeed, electronegativity increases along the row of the periodic table. Electronegativity decreases slowly along the column of periodic table except for the metals in the columns containing Cr, Mn, Fe, Co, Ni, Cu, Zn at top row. Understanding the explicit dependence between $\chi(X)$ and $a_B(x)$ and other parameters involved would require a more detailed model.

6.3.3 Deducing an estimate for the value of $n = h_{eff}/h$ from bond lengths

Valence bond lengths provide information allowing to estimate the value of $n = h_{eff}/h$.

i. The expectation is that the bond length for bond A-B scales as the minimum of Bohr radius for the two atoms that is minimum value of $a_B \propto n^2m^2/Z^2$ for atoms A and B. Here one has $n = h_{eff}/h$, m (usually n) denotes the principal quantum number of valence electron, and Z the charge of the atomic nucleus. The atom with smaller value of m/Z should dictate the bond length.

ii. If bond length assumed to be of order Bohr radius as function of (Z_{eff}, m), its reduction as function of m/Z_{eff} is quite too slow to be consistent with m^2/Z^2_{eff} behavior expected for ordinary Planck constant (see the table of `http://tinyurl.com/pbh6r6c`). The formula $a_B \propto n^2m^2/Z^2_{eff^2}$ and the increase of n as function of Z_{eff} compensating the reduction of a_B due to the increase of Z_{eff} for valence bonds is suggestive.

The first guess is that the formula $a_B(nZ_{eff}/m) = a_H$ holds true apart from factor of order 2. This would explain why valence bond lengths vary in so narrow length scale range. This fact could be even seen as argument against the reduction of chemistry to atomic physics.

The model is based on the following arguments.

i. The value of n is same for both atoms at the ends of the bond. Since the Bohr radius of atom with smaller value of nm/Z_{eff} gives rise to a smaller de-localization length of orbitals, the value of n for heavier atom, call it X, determines the length of flux tube which should be of order $2 \times a(X)$. Since the Bohr radius of the atoms with larger value of nm/Z_{eff} is longer, the electrons of this atom are more de-localized and tend to be nearer to atom with the smaller value of nm/Z_{eff}. The higher the value of Z with same value of m for both atoms the higher the electronegativity. This conforms with empirical facts.

ii. The electronegativity of H is roughly twice the electronegativity of the alkali-atoms in the above example. The naïve application of the above argument this would suggest that nm/Z_{eff} for alkali atoms must be larger than n so that de-localization of electron of alkali atom would make hydrogen atom more electronegative. This of course cannot be the case. The solution of the problem is that one cannot apply the

rule without taking into account valence rule. For C, N, O, F and S, Cl the electronegativities are higher than for H. Note that one has $\chi(P) = 2.19 \sim \chi(H) = 2.20$. Interestingly, P occurs with valence 5 in phosphate.

iii. $n(H) = 6$ suggested by the findings of Mills [D11] [L15] and will be assumed.

With these assumptions, one can consider two options fixing the value of $n(X)$ using as a guideline empirical data about bond lengths telling that they vary in rather narrow rang $[2, 6]a_H$.

i. For Option I one would have $a(X) = a_B(H)$ implying that all Bohr radii and bond lengths are same and equal to those for hydrogen. Bond length would be in good approximation twice the hydrogen atom Bohr radius: $r = 2a_H$. This condition is satisfied approximately for quite a number of bond lengths. The radii however vary roughly in the range $[1, 3] \times 2a_H$.

Option I would give

$$n^2(X) = (\frac{Z_{eff}}{m})^2 n^2(H) \quad .$$

For given row characterized by the value of m one would have

$$n(Z, m) = \frac{Z_{eff} n_H}{m} = \frac{6Z_{eff}}{m} \quad .$$

ii. $n_H = 6$ proportionality for n allows besides $n = Z_{eff} n_H/m$ also more general option: call it Option II. One can have

$$n(X, \frac{k}{l}) = \frac{l}{k} \times n(Z_{eff}, m) = \frac{l}{k} \times \frac{6Z_{eff}}{m} \quad ,$$

where $k \in \{2, 3, 6\}$ is non-trivial divisor of $n_H = 6$ besides. This scales the Bohr radius $a(mn/Z_{eff}) = a_H$ to

$$a(mn/Z_{eff}) = (l/k)^2 a_H \quad .$$

For instance, $l/k = 3/2$ would give Bohr radius $a(X) = 9a_H/4$ somewhat above $2a_H$. $l/k = 4/3$ would give Bohr radius $16a_H/9$ and $l/k = 5/3$ would give Bohr radius $a(X) = 25a_H/9$ slightly below $2a_H$. The largest bond lengths are about $6a_H$. These two mechanisms could explain the variation of the bond length. This option would explain the bond lengths which $1 - 3$ times the minimal bond length $r = 2a_H$.

iii. The value of the Bohr radius is not affected much if $n(Z_{eff}, m)$ is replaced with the nearest integer. This because for large enough n one the relative change $\Delta r/r = \Delta a_B/a_B$ satisfies $\Delta r/r \simeq 2\Delta n/n = (2m/Z_{eff} n_H)\Delta n = (m/3Z_{eff})\Delta n$. This allows fine tuning of the bond length for both options.

Consider now different rows of the periodic table for Option I. The lengths for Option II can be deduced from this option by scaling by $(k/l)^2$, $l = 2, 3, 6$.

i. $m = 2$: For $X \in \{Li, Be, B, C, N, O, F\}$ with $Z_{eff} \in \{1, ..., 7\}$ and $m = 2$ one $n(Z_{eff}, m) = 3Z_{eff} \in \{3, 6, ..., 18, 21, \}$. The highest values of n are in this row and this might be of biological significance. Indeed, large n means large metabolic energy and C,N, and O are fundamental in metabolism.

ii. $m = 3$: For $X \in \{Na, Mg, Al, Si, P, S, Cl\}$ one has $m = 3$, $Z_{eff} \in \{1, .., 7\}$. One $n(Z_{eff}, m) = 2Z_{eff}$ $n(X) \in \{2, 4, ..., 14\}$. The common values of n are in $n = 6$ corresponding to Be and Al and to $n = 12$ corresponding to C and S: note that also S corresponds to large metabolic energy. Note that P and S with $n = 12, 14$ are also important in metabolism. Whereas the lighter atoms serve control purposes.

iii. $m = 4$: $X \in \{K, Ca, Sc\}$ have $Z_{eff} \in \{1, 2, 3\}$, metals $\{Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn\}$ have $Z_{eff} \in \{4, ..., 12\}$ and $\{Ga, Ge, As, Se, Br\}$ have $Z_{eff} \in \{13, ..., 17\}$ have $m = 4$. One has $n(Z_{eff}, m) = 3Z_{eff}/2$ having also half odd-integer values. This gives $\{1, 3/2, 2\}$ for $X \in \{K, Ca, Sc\}$ and $\{5/2, ..., 17/2\}$ for $\{Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn\}$ and $\{9, ..., 11\}$ for $\{Ga, Ge, As, Se, Br\}$. The total variation range for n is $[1/2, 11]$. Alkali atoms K, Ca and metals Mn, Fe, Co, Ni, Cu, Zn are biologically important. The corresponding metabolic energies are however not so large as for lower rows and this ions indeed seem to serve for control purposes. (Li,Be,B) and (V,Cu,Ga) have same values of n as also (Na,Mg,Al,Si,P) and (Sc,Mn,Co,Cu,As). Interestingly As is reported to play the role of P in some exotic metabolism.

One could understand the deviations of bond length from the ideal value by allowing small variations of $n(Z_{eff}, m)$. In particular, the replacement of half-odd integer with integer would not considerably affect the bond length.

iv. $m = 5$: For $m = 5$ the values of $n(Z_{eff}, m)$ are not integers for the proposed model unless Z_{eff} is divisible by 5. One has $Z_{eff} \in \{1, ..18\}$. The maximum integer value of n is 3. This allows only Nb, Pd,Sb. Could this relate to the fact that heavier atoms are not so important biologically? The atoms near these 3 atoms

v. $m = 6$: For $n_H = 6$ one has $n(Z_{eff}, m) = Z$ for $m = 6$ atoms. Could integer valuedness mean that these atoms might be somehow special?

vi. The scale of variation of n degreases with m and this suggests smaller scale of variation for both valence bond length and electron-negativity. The range for the variation of latter indeed decreases along the columns of the periodic table. Also the values of n decrease along the colum of the periodic table: also this conforms with the empirical facts.

To sum up, it seems that one can understand bond lengths quite satisfactory and deduce from the values of n if the proposed model is accepted. The most important outcome would be explanation for the fact that bond lengths do not scale like $(m/Z_{eff})^2$ as standard quantum theory would suggest.

6.3.4 About biological interpretation

$h_{eff}/n = n$ for valence bond serves as a kind of IQ and also for the metabolic energy carried by molecule in valence bonds. This suggests that biologically important molecules should have larger value n. One can test this hypothesis.

i. Difference in χ means that valence electrons are shifted toward the more electronegative atom of the valence bond. As found, the larger value of $a_B(nm/Z_{eff}))$ for the atom with smaller value of nm/Z_{eff} allows to understand why it is more electronegative.

ii. By the above proposal large value of mn/Z_{eff} corresponds to long valence bond and therefore de-localization of valence electron to long scales. The length of valence bond presumably depends also on other parameters. In any case, bond length could be taken as a rough indication about the value of n associated with the bond and the above estimate for n can serve as a starting point. The variation of bond length might allow interpretation in terms of variation of n.

iii. The shortest bond lengths would correspond to smallest value of n possibly assignable to what is identified as waste in metabolic reactions. Small value of n also means large binding energy so that the waste molecules in cellular respiration should have short valence bonds. High energy phosphate bond (...P-O-P...) between two phosphates - say in ADP and ATP - would correspond to a large value of n and the bond should be long. Note that P behaves as valence 5 element in phosphate.

Consider the possible implications in more detail.

i. $h_{eff}/n = n$ for valence bond serves as a kind of IQ and also for the metabolic energy carried by molecule in valence bonds. This suggests that biologically important molecules should have larger value n. One can test this hypothesis.

A. Difference in χ means that valence electrons are shifted toward the more electro-negative atom of the valence bond. As found, the larger value of $a_B(nm/Z_{eff})$) for the atom with smaller value of nm/Z_{eff} allows to understand why it is more electronegative.

B. By the above proposal large value of mn/Z_{eff} corresponds to long valence bond and therefore de-localization of valence electron to long scales. The length of valence bond presumably depends also on other parameters. In any case, bond length could be taken as a rough indication about the value of n associated with the bond and the above estimate for n can serve as a starting point. The variation of bond length might allow interpretation in terms of variation of n.

C. The shortest bond lengths would correspond to smallest value of n possibly assignable to what is identified as waste in metabolic reactions. Small value of n also means large binding energy so that the waste molecules in cellular respiration should have short valence bonds. High energy phosphate bond (...P-O-P...) between two phosphates - say in ADP and ATP - would correspond to a large value of n and the bond should be long. Note that P behaves as valence 5 element in phosphate.

D. C and Si atoms are expected to form linear polymer-like structures with long valence bonds and large and varying value of n proportional to $Z_{eff} \simeq n_V$, n_V the number of valence electrons and guaranteeing that the bond length has correct value varying in rather narrow range. Of course, bonding of atoms with additional atoms as occurs in multi-phosphates could allow also linear structures. This could partially explain why life is Carbon based.
The proposed valence theory allows a view about the role of C. The length of C-H bond is determined by $n(C)$ with larger $n_V(=4)$ so that the valence electron tends to be nearer to C: $\chi(C) = 2.55 \geq \chi(H) = 2.2$ conforms with this. $n(C-H) = n(C-C)$ predicted. The high negentropy of C-H bond could explain why also C-H bonds are so typical in biology. Note that petroleum consists of carbohydrates and liberates energy, supporting the view that non-standard value of n is associated with the valence bonds also in this case.
Graphite is obtained by putting 2-D graphene layers on each other. In graphite C has valence bonds to 4 C:s and in graphene to 3 C:s. An interesting question is whether this might relate to some very special properties of graphene and whether it might correspond to larger than usual value of n. Not that these structures, in particular graphite, are much less dynamical than polymers.

E. Si is second candidate for the basic atom of life. The values of n for C-H bonds and C-C bonds are in good approximation proportional to n_V/m and in ratio $n(m = 2, Z_{eff})/n(m = 3, Z_{eff}) \simeq 3/2$. $n(C) > n(Si)$ implies that C-H and C-C bonds are more negentropic and energetic favoring Carbon based life. Also the C-N and C-O bonds are more negentropic and energetic than Si-P and Si-S bonds.
Note also that $\chi(Si) = 1.9$ is smaller $\chi(H) = 2.20$ so that the electron is nearer to H making it effectively negatively charged. Silanes (hydrosilicons) are very reactive. Also this could relate to the fact that Si based life is not realized.

1. Redox reaction and energy metabolism

Oxidation means the transfer of electrons towards more electronegative atom - not necessary oxygen - and means shorter de-localization scale for electrons and shorter bond unless the value of n increases.

A. Oxidation happens when nutrients are catabolized so that they give the metabolic energy stored into the valence bonds, which could be rather stable due to the non-standard value of n. This rule would hold true quite generally. Biocatalysis would temporarily reduce the value of n for various bonds and liberate energy allowing to kick the reacting molecules over the potential wall preventing the reaction.

B. Aerobic cell respiration relies on oxygen. At the bottom of the catabolic cascade is glucose C_6H_{12} O_6 decomposed into CO_2 =O=C=O and water. The liberated energy is used to transform ADP to ATP. C=O group acts as the functional group because C is effectively slightly positively charged and attracts negative ions and negative parts of molecules so that it is highly reactive. C=O bond length is 116 pm and considerably shorter than C-O bond length (in say C-O-H) (about 143 pm in paraffin, see `http://tinyurl.com/y95bkooa`). This conforms with the assumption that n is smallest in CO_2 so that in this sense it would be waste.
Note however that the value of n is higher than $n = n_H = 6$ (taking seriously the findings of Mills [D11] [L15] also for O in CO_2. This should relate to the special role of CO_2 and $H_2(O)$ concerning life. In fact, in both cases the value of $n(O)$ for bonds involved is almost maximal possible in the entire periodic table. Only F has larger n but is too reactive. Hence O is optimal choice both negentropically and energetically. S is second candidate for the role of O but $n(S)$ is by factor 2/3 smaller. Hence $m = 2$ row of the periodic table is optimal for life.
Remark: A rough estimate of the proposed valence bond theory for the ratio of the values of n for C-C and C-O bonds assuming that all bonds have the same length would be $n_V(O)/n_V(C) = 3/2$.

C. The waste products of metabolism should consist of compounds, which do not have C-C bonds, in particular molecules having only single C atom. The flux tubes associated with the valence bonds should have low value of n and correspond to low molecular IQ. Bond lengths and de-localization lengths should be short. The molecules should involve typically single carbon atom or no carbon atoms.
Carbon di-oxide CO_2 with valence structure O=C=O represents basic example about outcome of oxidation. CO_2 is the basic organic waste product of metabolism and indeed has especially short bond length. C=O group is functional since oxidation makes C slightly positively charged so that it attracts negative ions and negatively charged parts of molecules. Also ammonium NH_3 is waste product and now electrons are shifted towards N as one finds by comparing the electronegative of H and N appearing in the table of Wikipedia article (see `http://tinyurl.com/pbh6r6c`). As already noticed, the notion of "waste" is only relative notion.
Urea (H_2-N)-C(=O)-(N-H_2) is second waste product. As a matter of fact, liver forms urea and water by combing CO_2 with two NH_3 (ammonium) molecules. Liver puts two waste molecules to single packet.

D. Also H_2O has high negentropy and energy contents although it appears as "waste" in cell respiration. The presence of hydrogen bonds between water molecules gives rise to dark protons, which also affects the situation. Photosynthesis indeed has water and CO_2 input elements so that it makes sense for them to have high negentropy and energy content.
Remark: Solar light would generate negatively charged exclusion zones of Pollack [L4] [L4] crucial for life.

One can look the situation also from the view point of storage of metabolic energy and negentropy.

A. Hydroxy group O-H (see `http://tinyurl.com/y7uv924k`) attached to C appears in sugars with chemical formula $C_nH_{2n}O_n$. For the simplest hydrocarbons one would have formula C_nH_{2n} apart from boundary corrections at the ends of the polymer. Sugars store more metabolic energy than hydrocarbons and the valence theory should allow to understand this. The rough estimate of the proposed valence bond theory for the ratio of the values of n for C-O and C-H assuming that all bonds have the same length would be $n_V(O)/n_V(C) = 3/2$. This predicts that sugars are more negentropic and energetic than hydrocarbons.

B. C-O bond length is in the range [143,215] pm and C-H bond in the range [106,112] pm. The value of n for C-O-H bond must be higher than predicted by the assumption that the bonds have equal lengths. The replacement $n(O) \to 3/2n(O)$ allowed by $n_H = 6$ would predict that the ratio of C-H and C-O bond lengths is 9/4. Smaller variations of $n(O)$ are also possible. This would increase further the negentropy and energy contents of O and conform with Negentropy Maximization Principle (NMP), whose statistical form is a prediction of adelic TGD [L28] [L29].

C. The Wikipedia article about hydroxy group tells that compounds containing hydroxyl groups (O-H) tend to form hydrogen bonds forcing them to stick together. This would mean formation of dark protons and suggests formation of flux tube networks, which could be also behind the formation of water molecule clusters and be fundamental aspect in the formation of systems with life-like properties [L25] (see `http://tinyurl.com/yassnhzb`). O-H is thus favored over H also for this reason.

D. One can understand also the somewhat mysterious high energy phosphate bond. Phosphate has chemical formula $(P{=}O)O_3^-$. In phosphate the contents of metabolic energy and negentropy are maximized for the proposed model for valence bonds since only F has higher value of n than O in the periodic table assuming that bond lengths are identical. The actual bond lengths require that the value of $n(O)$ is even higher than this.

2. DNA, RNA, and amino-acids

What about other biomolecules such as DNA and amino-acids?

A. DNA (see `http://tinyurl.com/cpndtse`) involves the backbone consisting of a sequence of phosphates $(P{=}O)O_3^-$ and ribose molecules. The 6-cycles of ribose molecules contain 5 carbon atoms and one oxygen atom. As already noticed, phosphate has very high energy and negentropy contents. P has very nearly the same electronegativity (2.19) as H (2.20) and O has electronegativity 3.44 so that the P-O bonds resemble H-O bonds as far electronegativity is considered.

   The aromatic 5- and 6-cycles of DNA involving de-localized electrons contain two N atoms besides C atoms. The electro-negativities are $\xi(C) = 2.55$ and and $\xi(N) = 3.04$ so that electrons should be nearer to N. The length of C-N bond is longer than C-C bond so that the values of n could be the same and n for C-N bond could be even higher than for C-C bond so that it would be more negentropic. This could explain why nitrogens are present in DNA rings rather than only carbon atoms. Note that DNA strands are connected by $N\cdots N$ and $N\cdots O$ hydrogen bonds possibly involving dark protons.

   In RNA (see `http://tinyurl.com/cmvyw2r`) one C-H in the ribose is replaced with C-O-H in pentose ring. A, T, C, G are replaced with A, U, C, G (T is methylated form of U obtained by replacing -H with $-CH_3$). Only short strands of RNA appear and RNA does not have double stranded form but has single stranded form forming double helix. An interesting question is why the replacement of C-H with C-O-H in the pentose inducing change in electronic charge distribution affects so dramatically the properties of DNA. O-H group is functional and involved with the formation of hydrogen bonds. Maybe quantum criticality of ribose has something to do with the widely different properties of DNA and RNA.

B. Amino-acids (see `http://tinyurl.com/jsphvgt`) have structural formula H_2N-((C-H)-R)-((C=O)H)-OH, where R is the residue responsible for the functional properties of the amino-acid. Amino-acid polymers have backbone involving N-C bonds formed between amino-group N-H_2 and carboxyl group (C(=O)H)-OH by hydrolysis giving rise to peptide bond ...(C(=O)H)-NH... plus H_2O. Therefore the backbone consists of ...-(C(=O)H))-(NH)-...-(C(=O)H))-(NH)... sequence containing ((C-H)-R) between molecules of the backbone.

Assuming same N-C and C-C bond lengths the proposed valence band theory predicts $n(N) = (n_V(N)/n_V(C)) = 5n(C)/4$ implying that higher content of metabolic energy and negentropy favors C-N bonds instead of C-C bonds. That the catabolism of peptides to sugars liberates metabolic energy conforms with this.

6.3.5 About the biological role of low valence ions

A comment about the role of biologically important ions is in order. As a rule they tend to have low valence, especially those whose cyclotron frequencies for $B_{end} = .2$ Gauss seem to be important biologically. The possibly existing valence bonds between atoms towards the left end of the rows of the periodic table (Li,Na,K,Ca, Mg,..) - if they even exist at all - have low valence and low value n satisfying $n \geq 6$ (note that the valence of the bond is the valence of the atom with higher valence).

A. The potential negentropy content of low valence bonds is low and also metabolic energy content defined as difference of energy from the situation in which one has $n = 6$ derived from the experiments of Randell Mills [L15]. Thus low valence bonds are not important for metabolism.

B. Low valence ions have however different role: they appear as biologically important positive ions important for the communications to and control by MB. For instance, dark photons with cyclotron frequencies in magnetic fields of flux tubes would be involved with control by dark photons. These dark photons could also transfer energy to MB. The values of n for dark photons can be as high as $n \sim 10^{12}$ or even higher from the condition that the energies of dark photons with frequencies in EEG range are above thermal energy or even in visible and UV range for bio-photons.
Values of n for dark ions could be thus much higher than for electrons at valence bonds if their cyclotron energies correspond to dark photon energies. Dark photons and dark cyclotron condensates would represent a higher level of evolutionary hierarchy and control and coordination in quite long length scales responsible for the quantum coherence of living matter.
Remark: Recall that the assumption $\hbar_{eff} = \hbar_{gr} = GMm/v_0$, where $v_0 > c$ has dimensions of velocity, m mass of the charged particle, and M some large mass, guarantees universality of cyclotron energy spectrum (spectrum of bio-photons in visible and UV range). This gives $n \sim 10^{13}$ for 10 Hz cyclotron frequency photon energy about 1 eV. Fe^{++} has $f_c = 10$ Hz in $B_{end} = .2$ Gauss.

1. Some examples about biologically important ions

One can consider some examples about biologically important ions.

A. In TGD protons H^+ appear as dark protons. The small value of the atomic binding energy would explain why hydrogen appears as ion: dark atoms with this value of n would have extremely large size. Dark protons need not of course have the value of n characterizing dark EEG photons. Rather, entire hierarchy of frequency scales is expected ranging down to the energies of IR photons still above the thermal energy.

B. Hydrogen bond carrying de-localized proton would serve as the simplest example and be associated with magnetic flux tube. Hydrogen bonded water molecule clusters are crucial for life. Hydrogen bonds are also formed between OH groups of say water and some other high valence atoms.
Dark DNA/RNA/amino-acid/tRNA realized as dark proton sequences at magnetic flux tubes and realizing vertebrate genetic code (prediction) would be second realization giving rise to dark nuclei [L11]. Cell membrane as generalized Josephson junction would involve electronic Cooper pairs and dark protons or even their Cooper pairs [K42]. At microscopic level membrane proteins defining various ion channels and pumps would act as generalized Josephson junctions.

C. What about heavier ions? Their dark variants appear at MB and play a key role in TGD based model for quantum biology and neuroscience. They appear at flux tubes assignable to generalized Josephson junctions and at layers of MB in much longer scales (note that hydrogen bond is analogous to Josephson junction). Dark ions carrying much more information in BE condensates than dark valence electrons would serve control purposes whereas dark electrons at valence bonds would carry metabolic energy.

D. What about noble gases? Can one say that they have maximal valence or do they have vanishing valence and therefore $n = 6$ as the findings of Mills suggest? If they had maximal valence they should be biologically important but they are not: thus $n = 6$ identification is feasible. Ions at the right end of the rows of periodic table, say Cl^- ion, are like noble gas atoms as far as valence is considered. The electronic negentropy of H-Cl understood as H^+ bonded with Cl^- (ionic bond rather than valence bond) and metabolic energy content would be minimal. Cl^- could however form cyclotron condensates with a large value of n, which would explain its biological importance.
Amusingly, plastic balls in plasma of Ar^+ ions appear in the experiment demonstrating life like properties of this system ("breathing") [L25]. Ar^+ would have maximal possible valence and thus maximal value of n and would appear at flux tubes.

2. How the ionization is possible in living matter?

The appearance of ions in living matter looks mysterious. Same is true concerning ions in electrolytes. It is easy to talk about cold plasma but much more difficult to answer the question how this cold plasma can be created. Usually the formation of plasma involves ionization, which requires high temperature of order of the atomic binding energy for the valence electrons of the atom. For hydrogen atom the binding energy is around 13 eV, which corresponds to a temperature of roughly 130,000 Kelvin! This is three orders of magnitude higher than room temperature! In electrolyte the presence of rather weak electric fields cannot explain why the ionization takes place.
For some reason chemists and biologists do not spend much time in pondering fundamentals and theoreticians enjoying monthly salary have a highly irreverent attitude to these disciplines as an intellectual entertainment of lower life-forms. Therefore also this question has been guided under the rug and stayed there.
TGD based explanation for the paradox is simple. If the value of $h_{eff}/h = n$ for valence electrons is high enough, the binding energy, which is proportional to $1/n^2$, becomes so high that a photon with rather low energy, say infrared (IR) photon, can be ionize the dark atom. One can say that the atoms in this state are quantum critical, a small perturbation can ionize them.

A. In the TGD based model of cold fusion as dark nucleosynthesis the atoms would have $n = 2^{12} = 2056$ and the ionization would create dark nuclei as sequences of dark protons at magnetic flux tubes [L20].

B. In the TGD based model for the analogs of DNA/RNA/amino-acid sequences/tRNA as dark proton sequences the value of n would be of the order of 10^6 higher so that the distance between dark protons, would be a same as between DNA letters, about 3 Angstroms. For these values of n dark atoms are unstable at room temperatures.

C. In Pollack effect [L4] the irradiation by IR light or visible light or by pumping energy to the system by some other means produces negatively charged exclusion zones (EZs) in which water molecules form hexagonal layers and obey the effective stoichiometry $H_{3/2}$ O. Part of protons (every fourth) goes to magnetic flux tubes as dark protons. How it is possible to create this state by IR radiation?

A. The original assumption was that in second OH bond of water molecule

is excited to a high energy state near to ionization energy so that IR photon can split the bond. The question is: why and how? Do the UV photons from solar radiation cause the excitation?

B. A more elegant option is that the value of n for the second O-H bond is so large that the bond binding energy is so small that IR photon can split the bond. Solar UV photons could induce the dark excitation. Taking 5 eV as rough estimate for the bond binding energy in the normal state water, this requires the reduction of energy by a factor of order 10^3 to give IR energy .05 eV (energy scale assignable to the membrane potential eV). n would increase by factor of order $2^5 = 32$ from its value for O-H bond according to standard chemistry. A small push by absorption of IR photon can split the O-H bond and create dark proton at flux tube. Any perturbation feeding to the system this energy can induce the kicking of dark proton to flux tube. The generalization of this mechanism to various atoms could be one of the basic mechanisms of quantum criticality in living matter.

6.4 A New Control Mechanism Of TGD Inspired Quantum Biology

The idea that TGD Universe is quantum critical, is the corner stone of quantum TGD and fixes the theory more or less uniquely since the only coupling constant parameter of the theory - Kähler coupling strength - is analogous to critical temperature. Also more than one basic parameters are in principle possible - maximal quantum criticality fixes the values of all of them - but it seems that only Kähler coupling strength is needed. TGD Universe is a quantum critical fractal: like a ball at the top of hill at the top of hill at.... Quantum criticality allows to avoid the fine tuning problems plaguing as a rule various unified theories.

6.4.1 Quantum criticality

The meaning of quantum criticality at the level of dynamics has become only gradually clearer. The development of several apparently independent ideas generated for about decade ago have led to the realization that quantum criticality is behind all of them. Behind quantum criticality are in turn number theoretic vision and strong forms of general coordinate invariance and holography.

A. The hierarchy of Planck constants defining hierarchy of dark phases of ordinary matter corresponds to a hierarchy of quantum criticalities assignable to a fractal hierarchy of sub-algebras of super-symplectic algebra for which conformal weights are n-ples of those for the entire algebra, n corresponds to the value of effective Planck constant $h_{eff}/h = n$. These algebras are isomorphic to the full algebra and act as gauge conformal algebras so that a broken super-conformal invariance is in question.

B. Quantum criticality in turn reduces to the number theoretic vision about strong form of holography. String world sheets carrying fermions and partonic 2-surfaces are the basic objects as far as pure quantum description is considered. Also space-time picture is needed in order to test the theory since quantum measurements always involve also the classical physics, which in TGD is an exact part of quantum theory.
Space-time surfaces are continuations of collections of string world sheets and partonic 2-surfaces to preferred extremals of Kähler action for which Noether charges in the sub-algebra of super-symplectic algebra vanish. This condition is the counterpart for the reduction of the 2-D criticality to conformal invariance. This eliminates huge number of degrees of freedom and makes the strong form of holography possible.

C. The hierarchy of algebraic extensions of rationals defines the values of the parameters characterizing the 2-surfaces, and one obtains a number theoretical realization of an evolutionary hierarchy. One can also algebraically continue the space-time surfaces to various number fields - reals and the algebraic extensions of p-adic number fields. Physics becomes adelic. p-Adic sectors serve as correlates for cognition and imagination. One can indeed have string world sheets and partonic 2-surfaces, which can be algebraically continued to preferred extremals in p-adic sectors by utilizing p-adic pseudo constants giving huge flexibility. If this is not possible in the real sector, figment of imagination is in question! It can also happen that only part of real space-time surface can be generated: this might relate to the fact that imaginations can be seen as partially realized motor actions and sensory perceptions.

6.4.2 Quantum criticality and TGD inspired quantum biology

In TGD inspired quantum biology quantum criticality is in crucial role. First some background.

A. Quantum measurement theory as a theory of consciousness is formulated in zero energy ontology (ZEO) and defines an important aspect of quantum criticality. Strong form of NMP states that the negentropy gain in the state function reduction at either boundary of causal diamond (CD) is maximal. Weak form of NMP allows also quantum jumps for which negentropic entanglement is not generated: this makes possible ethics (good and evil) and morally responsible free will: good means basically increase of negentropy resources.

B. Self corresponds to a sequence state function reductions to the same boundary of CD and h_{eff} does not change during that period. The increase of h_{eff} (and thus evolution!) tends to occur spontaneously, and can be assigned to the state function reduction to the opposite boundary of CD in zero energy ontology (ZEO). The reduction to the opposite boundary means death of self and living matter is fighting in order to avoid this even. To me the only manner to make sense about basic myth of Christianity is that death of self generates negentropy.

C. Metabolism provides negentropy resources for self and hopefully prevents NMP to force the fatal reduction to the opposite boundary of CD. Also homeostasis does the same. In this process self makes possible evolution of sub-selves (mental images dying and re-incarnating) state function by state function reduction so that the negentropic resources of the Universe increase.

6.4.3 A new mechanism of quantum criticality

Consider now the mechanisms of quantum criticality. The TGD based model [L8] [**?**] (`http://tinyurl.com/y8oblpl9`) for the recent paradoxical looking finding [L8] (`http://tinyurl.com/y79qo7lp`) that topological insulators can behave like conductors in external magnetic field led to a discovery of a highly interesting mechanism of criticality, which could play a key role in living matter.

A. The key observation is that magnetic field is present. In TGD framework the obvious guess is that its flux tubes carry dark electrons giving rise to anomalous currents running in about million times longer time scales and with velocity, which is about million times higher than expected. Also supra-currents can be considered.
   The currents can be formed of the cyclotron energies of electrons are such that they correspond to energies near the surface of the Fermi sphere: recall that Fermi energy for electrons is determined by the density of conduction

electrons and is about 1 eV. Interestingly, this energy is at the lower end of bio-photon energy spectrum. In the field of 10 Tesla the cyclotron energy of electron is .1 mV so that the integer characterizing cyclotron orbit must be $n \simeq 10^5$ if conduction electron is to be transferred to the cyclotron orbit.

B. The assumption is that external magnetic field is realized as flux tubes of fixed radius, which correspond to space-time quanta in TGD framework. As the intensity of magnetic field is varied, one observes so called de Haas-van Alphen effect (`http://tinyurl.com/ych7b9n8`) used to deduce the shape of the Fermi sphere: magnetization and some other observables vary periodically as function of $1/B$ (for a model for the quantum critical variant of the effect see [D16]).
This can be understood in the following manner. As B increases, cyclotron orbits contract. For certain increments of $1/B$ $n+1$:th orbit is contracted to n:th orbit so that the sets of the orbits are identical for the values of $1/B$, which appear periodically. This causes the periodic oscillation of say magnetization.

C. For some critical values of the magnetic field strength a new orbit emerges at the boundary of the flux tube. If the energy of this orbit is in the vicinity of Fermi surface, an electron can be transferred to the new orbit. This situation is clearly quantum critical.
If the quantum criticality hypothesis holds true, $h_{eff}/h = n$ dark electron phase can be generated for the critical values of magnetic fields. This would give rise to the anomalous conductivity perhaps involving spin current due to the spontaneous magnetization of the dark electrons at the flux tube. Even super-conductivity based on the formation of parallel flux tube pairs with either opposite or parallel directions of the magnetic flux such that the members of the pair are at parallel flux tubes, can be considered and I have proposed this a mechanism of bio-superconductivity and also high Tc super-conductivity.

6.4.4 A new mechanism of quantum bio-control

The quantum criticality of the process in which new electron orbit emerges near Fermi surface suggests a new mechanism of quantum bio-control by generation of super currents or its reversal.

A. In TGD inspired quantum biology magnetic body uses biological body as motor instrument and sensory receptor and EEG and its fractal variants with dark photons with frequencies in EEG range but energy $E = h_{eff}f$ in the range of bio-photon energies make the necessary signalling possible.

B. Flux tubes can become braided and this makes possible quantum computation like processes [K1]. Also so called 2-braids - defined by knotted 2-surfaces imbedded in 4-D space-time surface - are possible for the string world sheets defined by flux tubes identified to be infinitely thin, are possible. As a matter fact, also genuine string world sheets accompany the flux tubes. 2-braids and knots are purely TGD based phenomenon and not possible in superstring theory or M-theory.

C. It is natural to speak about motor actions of the magnetic body. It is assumed that the flux tubes of the magnetic body connect biomolecules to form a kind of Indra's web explaining the gel like character of living matter. h_{eff} reducing phase transitions contract flux tubes connecting biomolecules so that they can find each other by this process and bio-catalysis becomes possible. This explains the mysterious looking ability of bio-molecules to find each other in the dense molecular soup. In fact the dark matter part is far from being soup! The hierarchy of Planck constants and $h_{eff} = h_{gr}$ hypothesis imply that dark variants of various particles

with magnetic moment are neatly at their own flux tubes like books in shelf.

Reconnection of the U-shaped flux tubes emanating from two subsystems generates a flux tube pair between them and gives rise to supracurrents flowing between them. Also cyclotron radiation propagating along flux tubes and inducing resonant transitions is present. This would be the fundamental mechanism of attention.

D. I have proposed that the variation of the thickness of the flux tubes could serve as a control mechanism since it induces a variation of cyclotron frequencies allowing to get in resonance or out of it. For instance, two molecules could get in flux tube contact when the cyclotron frequencies are identical and this can be achieved if they are able to vary their flux tube thickness. The molecules of immune system are masters in identifying alien molecules and the underlying mechanism could be based on cyclotron frequency spectrum and molecular attention. This would be also the mechanism behind water memory and homeopathy (`http://tinyurl.com/yda3d6se` [K23] which still is regarded as a taboo by mainstreamers.

E. Finally comes the promised new mechanism of bio-control. The variation of the magnetic field induced by that of flux tube thickness allows also to control whether there is quantum criticality for the generation of dark electron supra currents of electrons. The Fermi energy of the conduction electrons at the top of Fermi sphere is the key quantity and dictated by the density of these electrons. This allows to estimate the order of magnitude of the integers N characterizing cyclotron energy for ordinary Planck constant and the maximal value of $h_{eff}/h = n$ cannot be larger than N.

6.5 Are Bacteria Able To Induce Super-Fluidity?

Nature News (see `http://tinyurl.com/nhcmkle`) tells t hat a team led by Auradou *et al* reports in the article "Turning Bacteria Suspensions into Superfluids" [I4] published in Phys Rev Letters (see `http://tinyurl.com/ycfm8gnn`) that bacterium swimming in fluid do not only reduce its viscosity associated with shear stress (viscous force parallel to the surface) but makes it to behave in super-fluid like manner above a critical concentration of bacteria.

As the number of bacteria (E. coli) was increased, the viscosity associated with shear stress (the viscous force parallel to the surface) dropped: this in accordance with theoretical expectations. Adding about 6 billion cells (the fluid volume is not mentioned but it seems that the effect occurs above critical density of bacteria), the apparent viscosity dropped to zero - or more precisely, below the experimental resolution. The super-fluid like behavior was preserved above the critical concentration. What is important that this did not happen for dead bacteria: bacteria play an active role in the reduction of viscosity.

Researchers are not able to identify the mechanism leading to the superfluid-like behavior but some kind of collective effect is believed to be in question. The findings suggest that the flagellae - kind of spinning hairs used by the bacteria to propel themselves - should play an essential part in the phenomenon. As bacteria swim, they fight against current, decreasing the local forces between molecules that determine the fluid's viscosity. Above critical density the local effects would somehow become global.

Cates *et al* have proposed this kind of phenomenon: see the article "Shearing Active Gels Close to the Isotropic-Nematic Transition" (see `http://tinyurl.com/y9e3xl9v`) [I8]. The authors speak in the abstract about zero apparent viscosity.

A. The title of the article of Cates *et al* tells that the phenomenon occurs near isotropic-nematic transition. Nematic is defined as a liquid crystal

for which the molecules are thread-like and parallel. I dare guess that in the recent case the approximately parallel flagellae would be modelled as liquid crystal like 2-D phase at the surface of bacterium. In the isotropic phase the orientations of the flagellae would be uncorrelated and long range orientational correlations would emerge in the phase transition to nematic phase.

B. Also the notions of contractile and extensile gels are introduced. Contraction and extension of gels are though to occur through molecular motors. The transformation of the fluid to apparent superfluid would require energy to run the molecular motors using metabolic energy and ordinary superfluidity would not be in question.

C. The model predicts divergence of viscosity for contractile gels. For extensile gels a zero of apparent viscosity is predicted. There is a hydrodynamical argument for how this would occur but I did not understand it. The active behavior of the bacteria would means that the gel like surface phase (nematic liquid crystal) formed by the flagellae extends to reduce viscosity. If I have understood correctly, this applies only to the behavior of single bacterium and is about the reduction of viscosity in the immediate vicinity of cell.

My deep ignorance about rheology allows me freedom to speculate freely about the situation in TGD framework.

A. In TGD inspired biology gel phase corresponds to a phase, which involves flux tube connections between basic units. Flux tubes contain dark matter with non-standard value $h_{eff} = n \times h$. The h_{eff} changing phase transitions scaling the lengths of flux tubes proportional to h_{eff} are responsible for the contractions and extensions of gel.
The extension of the gel should lead to a reduction of viscosity since one expects that dissipative effects are reduced as h_{eff} increases and quantum coherence is established in longer scales. Large h_{eff} phases are associated with criticality. Now the criticality would be associated with isotropic-nematic phase transition. The parallelization of flagellae would be due to the quantum coherence assignable with the flagellae.
Note that the mechanism used by bacteria to control the liquid flow would be different since now molecular motors are replaced by h_{eff} changing phase transitions playing key role in TGD inspired view about biochemistry. For instance, reacting biomolecules find each other by h_{eff} reducing phase transition contracting the flux tubes connecting them.

B. This model does not yet explain the reduction of apparent viscosity to zero in the entire fluid occurring above a critical density of bacteria. What could happen could be analogous to the emergence of high T_c superconductivity according to TGD [K41] (`http://tinyurl.com/ycm6ao76`). Below pseudo gap temperature the emergence of magnetic flux tube pairs makes possible super-conductivity in short scales. At critical temperature a phase transition in which flux tubes reconnect to form larger thermodynamically stable networks occurs. One can speak about quantum percolation.
The reduction of viscosity for a single bacterium could be based on the phase transition of liquid molecules to dark molecules flowing along the resulting flux tubes with very small friction (large $heff$) but only below certain scale smaller than the typical distance between bacteria. This would be the analog for what happens below pseudo gap. Above critical density he magnetic flux tubes associated with bacteria would reconnect and forming a net of connected flux tube paths at scale longer than inter-bacterial distances. This would be the counterpart for the emergence of superconductivity by percolation in long scales.

6.6 Bacteria behave like spin system: Why?

In Physorg there was an interesting article titled "Bacteria streaming through a lattice behave like electrons in a magnetic material" (see `http://tinyurl.com/hysxsl6`). The popular article tells about article with title Ferromagnetic and antiferromagnetic order in bacterial vortex lattices by Dunkel *et al* [I9] (see `http://tinyurl.com/ydbzvmcc`) . The following summarizes what has been studied and observed.

A. The researchers have studied a square lattice of about 100 wells with well radius below 50 microns and well depth about 18 microns. The wells are connected by thin channels. Also triangular lattice has been studied.

B. Below a critical radius about 35 microns an ordered flow is generated. The flow involves interior flow and edge flow in opposite direction consisting of single bacterium layer. One can understand this from angular momentum conservation. The coherence of this flow is however surprising. If one believes that each bacterium in principle chooses its swimming direction, one must understand what forces bacteria to select the same swimming direction.

C. Below a critical radius of channel about d=4 microns the flow directions in the neighboring wells are opposite for the square lattice. One has superposition of lattice and its dual with opposite flow directions. In the case of triangular lattice analogous cituation is encountered. In this situation there is no flow between the wells but there is an interaction. The minimization of dissipative losses requires minimization of velocity gradients inside channels. made possible by same local flow direction for the edge currents of neighboring wells.

D. Above the critical radius the flow changes its character. The flows synchronize and the interior flows rotate in the same direction as do also edge flows which occur also between the neighboring channels and give rise to closed flows around the boundaries of square like regions behind wells having larger scale. This flow pattern is consistent with angular momentum conservation: the angular momenta of lattice and its dual cancel each other.

E. The phase transition is analogous to that from antiferromagnetism to ferromagnetism. The total angular momenta of bacteria, their colonies, are analogous to spins. The situation can be modelled as 2-D Ising model consisting of lattice of spins with nearest neighbor interactions. Usually the spins are assigned with electrons but now they are assigned with bacteria.

This raises interesting questions. Bacteria swim by using flagellae. They can decide the swimming direction and control it by controlling the flagellae. Bacteria are living organisms and have a free will. Why would bacterium colory behave like quantal many-spin system. What happens when the swimming direction becomes same for the bacteria inside single well: does the colony become an entity with collective consciousness and do bacteria obey "social pressure". Does this happen also for the colony formed by these colonies in transition to ferromagnetism like state?

If one takes TGD inspired quantum biology as starting point, one can represent more concrete questions and possible answers to them.

A. Magnetic body (MB) controls the biological body (BB) be it organism or part of it [**?**]. MB contains dark matter as cyclotron Bose-Einstein condensates of bosonic ions. Pairs of parallel flux tubes could also contain members of Cooper pairs whose spin depends on whether the magnetic fields at flux tubes are parallel or antiparallel [K40, K41].

B. What could be the mechanism of control? MB is assumed to send dark photon signals from MB to biological body to control it and an attractive idea is that control is by angular momentum conservation. Since the an-

gular momentum transfer involve is due to a phase transition analogous to the change of the direction of magnetization or generation of magnetization the angular momentum transfer is large irrespective of the value of unit of angular momentum for dark photon (see discussion below). This large angular momentum could be transformed to angular momentum of ordinary matter and in recent case be responsible for generating the rotational motion of bacterium or larger unit.

The transfer of dark photons induced by a phase transition changing the direction of dark magnetization might thus induce a large transfer of angular momentum to BB and generate macroscopic rotation. If this were the case the rotational state of dark MB of bacterium would serve as a template for bacterium.

The bacterium colony associated with the well below critical size would correspond to super-organism having MB whose rotational state could serve as template for the bacterial MBs in turn serving as a similar template for the bacteria.

C. If the net angular momenta of MB and corresponding BB (bacterium, well colony, colony of these) vanish separately, the model is consistent with the model of the article in which local considerations determine the rotational directions. In this case the MBs of well colonies would behave like spins with nearest neighbor interactions.

One can also consider the possibility that at quantum criticality long range quantum fluctuations occur and the local equilibrium conditions do not hold true. Even more, the net angular momenta of MB and BB would cancel each other but would not necessarily separately. This would imply apparent non-conservation of angular momentum at the level of bacterium colony at criticality and might allow to find experimental support for the notion of magnetic body. The proof of MB carrying dark matter as a concept would be very much like that of neutrino the existence of which was deduced from apparenent energy non-conservation in beta decays.

The model has a problem to worry about. I still am not quite sure whether $h_{eff}/h = n$ means that the unit of spin is scaled up by n or that a fractionization of angular momentum by $1/n$ for single sheet of associated n-fold covering of space-time surface takes place. The control mechanism based on angular momentum conservation could however be at work in both cases. The option assuming fractionization seems to be the realistic one and only this will be considered in the following. Reader can ponder the option assuming scaled up unit of angular momentum (the scaling up of angular momentum of dark photon is not in coherence with the assumption that dark photon has same four-momentum as ordinary photon to which it should be able to transform).

A. Consider first the simplest variant for the effective fractionization of quantum numbers. If one has n-fold covering singular at the boundaries of CD then spin fractionization can be considered such that one has effectively n spin $1/n$ photons - one per sheet - and the net spin is just the standard spin. This picture fits with the vision that the n-fold covering means that one must make n full 2π turns before turning to the original point at space-time sheet: this allows at space-time surface wave functions with fractional spin which would be many-valued in Minkowski space. Similar fractionization would occur to other quantum numbers such as four-momentum so that net four-momentum would not change. The wavelength of these building bricks of dark photon analogous to Bose-Einstein condensate have frequencies scaled down by factor $1/n$.

In this case the direct decay to single ordinary photon interpreted as biophoton is allowed by conservation laws. Of course, also decays to several ordinary photons are possible. The decay to a bunch of n ordinary photons with total momenta $1/n$ times that of dark photon is possible if the spins

of ordinary photons sum up to the spin of dark photon.

The total angular momentum liberated from the cyclotron Bose-Einstein condensate spin could be transferred to spin of ordinary particles, say proton or ion for which the natural scale of orbital angular momentum is much larger (proportional to the rest energy). Simple order of magnitude estimate for orbital angular momentum with respect to the symmetry axis of possibly helical magnetic flux tube shows that in this case the spin could be transformed to angular momentum in the scale of organism and to the motion of organism itself.

Note that dark photon could also decay to a bunch of ordinary photons with momentum scaled down by $1/n$ since the spins of the photons can sum up to spin 1.

B. A many-sheeted analog of second quantization generalizes the above picture. The n space-time sheets can be labelled by an integer $m = 1, ..., n$ defining an analog of discrete position variable. One can second quantize the fundamental fermions in this discrete space so that one has not only the ordinary many fermion states with $N = 0/1$ fermions in given mode but also states with fractionization of fermion number and other quantum numbers by $q = m/n < 1$ in a given mode. This would induce fractionization of bosons identified as fractional many-fermion states.

Particle with fractional spin cannot decay directly to ordinary particle unless one has m=n: this correspond to the first option. Fractional particles characterized by q and 1-q can however fuse to ordinary particle. An attractive additional hypothesis is that the net quantum numbers are integer multiples of the basic unit.

I have discussed the possibility of molecular sex: the opposite molecular sexes would have fractional charges summing up to ordinary charges. If magnetic bodies with opposite molecular sexes are paired they have ordinary total quantum numbers and can control ordinary matter by the proposed mechanism based on conservation of angular momentum (or some other charges). Dark matter would serve as template for ordinary matter and dark phase transitions would induce those of visible matter. The proposal that DNA, RNA, tRNA, and amino-acids are accompanied by dark proton sequences (or more general dark nuclei) could realize this picture. DNA double strand could be seen as an outcome of a molecular marriage in this framework! At higher level brain hemispheres might be a seen as a dark matter marriage. This picture can be also seen as emergence of symbols and dynamics based on symbol sequences at the molecular level with molecular marriage making possible very precise selection rules.

Two highly interesting findings providing insights about the origins of life have emerged and it is interesting to see how they fit to the TGD inspired vision.

The group led by Thomas Carell has made an important step in the understanding the origins of life. They have identified a mechanism leading to the generation of purines A and G which besides pyrimidines A,T (U) are the basic building bricks of DNA and RNA. The crucial step is to make the solution involved slightly acidic by adding protons. For year later I learned that a variant of Urey-Miller experiment with simulation of shock waves perhaps generated by extraterrestrial impacts using laser pulses generates formamide and this in turn leads to the generation of all 4 RNA bases.

These findings represent a fascinating challenge for TGD inspired quantum biology. The proposal is that formamide is the unique amide, which can form stable bound states with dark protons and crucial for the development of life as dark matter-visible matter symbiosis. Pollack effect would generate electron rich exclusions zones and dark protons at magnetic flux tubes. Dark protons would bind stably with unique amine leaving its chemical properties intact. This would lead to the generation of purines and the 4 RNA bases. This would

be starting point of life as symbiosis of ordinary matter and dark matter as large $h_{eff}/h = n$ phases of ordinary matter generated at quantum criticality induced by say extraterrestrial impacts. The TGD based model for cold fusion and the recent results about superdense phase of hydrogen identifiable in TGD framework as dark proton sequences giving rise to dark nuclear strings provides support for this picture.

There is however a problem: a reductive environment (with ability to donate electrons) is needed in these experiments: it seems that early atmosphere was not reductive. In TGD framework one can imagine two - not mutually exclusive - solutions of the problem. Either life evolved in underground oceans, where oxygen concentration was small or Pollack effect gave rise to negatively charged and thus reductive exclusion zones (EZs) as protons were transferred to dark protons at magnetic flux tubes. The function of UV radiation, catalytic action, and of shock waves would be generation of quantum criticality inducing the creation of EZs making possible dark $h_{eff}/h = n$ phases.

6.6.1 The first step: binding of dark protons to formamido-pyrimidine

I learned about very interesting discovery related to the problem of understanding how the basic building bricks of life might have emerged. RNA (DNA) has nucleotides A,G,C,U (T) as basic building bricks.

The first deep question is how the nucleotides A,G,C,U, and T emerged.

A. There are two types of nucleotides. Pyrimidines C and T/U (see `http://tinyurl.com/k3vxl9b`) have single carbon 6-cycle. Purines A and G (see `http://tinyurl.com/odvqw2p`) in turn have single 6-single and 5-cycle fused attached together along one side. Purines are clearly more complex than pyrimidines.

B. U.K. chemist John Sutherland demonstrated a plausible sequence of steps leading to the emergence of pyrimidines. Purines turned out to be more problematic. Leslie Orgel and colleagues suggested a possible pathway but it produces purines in too tiny amounts.

Now a group led by Thomas Carell in Ludwig Maximilian University have found a more plausible mechanism [I7] (see `http://tinyurl.com/z65kpyo`).

A. Carell and colleagues studied the interaction of biomolecule formamido-pyrimidine (FaPy) with DNA and found that it also reacts to produce purines. Could FaPys have served as precedessors of purines? (For formamide see `http://preview.tinyurl.com/lwqyqnu` and for the class of chemical compounds known as amines see `http://tinyurl.com/mad6c2u`).

B. The first step would have been a copious production of amino-pyrimidines containing several chemical groups known as amines. The problem is that the are so many amines and they normally react indiscriminantly to produce many different compounds. One wants mostly purines so that only one critical amine is wanted.

C. When Carell and his team added some acid to the solution to decrease its pH, a miracle happened. The extra protons from acid attached to the amines of the amino-pyrimidine and made them non-reactive. There was however one exception: just the amine giving rise to purine in its reactions! The reactive amine also readily bonded with formic acid acid (see `http://tinyurl.com/lmstt7n`) or formamide. Hence it seems that one big problem has been solved.

The second challenge is to understand how the building bricks of RNA and DNA combined to form longer polymers and began to replicate.

A. One prevailing vision is that so called RNA world preceded the recent biology dominated by DNA. The goal has been to achieve generation of RNA sequence in laboratory. Unlike DNA RNA sequences are not stable and long sequences are difficult to generate. DNA in turn replicates only

inside cell and the presence of what is known as ordered water seems to be essential for this.

B. This step might involve new physics and chemistry and I have considered the possibility that the new physics involves magnetic bodies and dark proton sequences as a representation of the genetic code at the level of dark nuclear physics. There is no need to add that the fact that dark proton states provide representations for RNA, DNA, tRNA, and amino-acids [K23, K31] looks like a miracle and I find still difficult to believe that it is true and for genetic code. Also the representation of vertebrate code emerges in terms of correspondences of dark proton states.
This suggests that the replication of DNA and takes place at the level of dark proton sequencies - dark nuclear strings - serving as a dynamical template for the biological replication. Also transcription and translation would be induced by dark process. Actually all biochemical processes could have as template the dynamics of molecular magnetic bodies and biochemistry would be kind of shadow of deeper dynamics.

C. There is actually support for dark proton sequences. Quite recently I learned about the article of Leif Holmlid and Bernhard Kotzias [L18] (see `http://tinyurl.com/hxbvfc7`) about the superdense phase of hydrogen. In TGD superdense phase has interpretation as dark proton sequences at magnetic flux tubes with the Compton length of dark proton coded by $h_{eff}/h \simeq 2^{11}$ to electron's Compton length [L6]. Remarkably, it is reported that the superdense hydrogen is super-conductor and super-fluid at room temperatures and even above: this is just what TGD predicts.
The dark protons in TGD inspired quantum biology [L9] should have much longer Compton length of order of the distance between nucleotides in DNA sequences in order to serve as templates for chemical DNA. This gives a dark Compton length of order $\simeq 3.3$ Angstroms from the fact that there are 10 codons per 10 nm. This gives $h_{eff}/h \simeq 2^{18}$.

One can return back to the first step in the genesis of DNA and RNA. The addition of protons to the solution used to model prebiotic environment to make it slightly acidic was the key step. Why?

A. Here cold fusion might help. Cold fusion is claimed to take place in electrolysis involving ionization and charge separation. The electric fields used in electrolysis induce ionization and thus charge separation. For me it has however remained a mystery how electric fields, which are extremely tiny using the typical strength of molecular electric field as standard are able to induce a charge separation. Of course, every chemist worth of his salt regards this as totally trivial problem. I am however foolish enough to consider the possibility that some new physics might be involved.

B. The mechanism causing charge separation could be analogous to or that discovered by Pollack as he irradiated water bounded by a gel phase [L4] [L4]: in the recent case the electric field would take the role of irradiation as a feeder of energy. Negatively charged exclusion zones (EZs) were formed and 1/4 of protons went somewhere.
The TGD proposal is that part of protons went to magnetic flux tubes and formed dark proton sequences identifiable as dark nuclear strings. The scaled down nuclear binding energy favours the formation of dark nuclear strings perhaps proceeding as analog of nuclear chain reaction. This picture allows to ask whether dark proton sequences giving rise to a fundamental representation of the genetic code could have been present already in water [L9]!

C. How DNA/RNA could have then formed? Could the protons making the solution acidic be dark so that the proton attaching to the amine would be dark? Could it be that for all amines except the right one the proton transforms to ordinary proton and destroys the chemical reactivity. Could

the attached dark proton remain dark just for the correct amine so that the amine would remain reactive and give rise to purine in further reactions? Could A,G,C,T and U be those purines and pyrimidines - or even more general biomolecules - for which the attachment to dark proton does not transform it to ordinary proton and in this manner affect dramatically the chemical properties of the molecule? What is the condition for the preservation of the darkness of the proton?

6.6.2 Second step: Could shock waves due to extraterrestrial impacts have produced RNA bases?

About year later I learned about a further interesting finding related to the prebiotic evolution (see the popular article at `http://tinyurl.com/m8npeor`). The conclusion of the research article (see [I10]) is that that the extraterrestrial impacts on Earth's early atmosphere might have generated all 4 RNA bases (see `http://tinyurl.com/kxxc7db`). Also now the formamide is involved and my layman guess is that the motivation for this comes from the experiment of Carell *et al* [I7] (see `http://tinyurl.com/z65kpyo`) discussed above. If formamide is generated then it becomes possible to generate formamido-pyridine and from this the RNA bases can be generated.

The experiment was a modern version of Urey-Miller experiment originally intended to simulate the situation at the surface of the early atmosphere modelled as a mixture a water H_2O, carbon-monoxide CO, and ammonium NH_3. The shock waves generated by the impacts were modelled in the experiment using terawatt laser pulses.

In the original Urey-Miller experiment amino-acids were generated. In the modern version of the experiment it was found that also formamide $CONH_3$ is formed, whose presence under suitable circumstances can lead to the generation of all 4 RNA bases. The presence of UV radiation, shock waves caused by extraterrestrial collisions, or of catalyst is the necessary condition.

In TGD Universe the additional condition could guarantee quantum criticality accompanied by dark $h_{eff}/h = n$ phases leading to the generation of dark protons and their stable binding with formamido-pyrimidine. The stable binding would not be possible for other amido-pyrimidines since dark protons would transform to ordinar protons for them. All 4 RNA bases would emerge from formamido-pyrimidine. All basic molecules of life could be produced in the reductive atmosphere.

The atmosphere was assumed to be reductive and this is a problem: the best that one can hope is that the early atmosphere was weakly reductive. Chemical compound is reductive (see `http://tinyurl.com/m9cqnob`) if it tends to donate electron. Reduction means receiving electron - and in chemistry hydrogen atom. To obtain a reducing atmosphere (see `http://tinyurl.com/lx4tat2`) one should remove oxygen from it. It however seems that the early atmosphere has contained oxygen and was oxidative rather than reductive. How could one overcome the problem?

A. In the experiment of Carell *et al* protons were added to reduce the pH of water. The basic experimental rule is that this makes the environment more reductive. The TGD proposal is that it led to a formation of dark proton-amine pair for the amine leading to the formation of purine. Charge separation by Pollack effect [L4] [L9] leading to the generation of dark proton sequences (dark nuclei) at magnetic flux tubes could have been due to the IR radiation, and maybe also by UV radiation, catalytic action, or by shock waves. The presence of electrons in the exclusion zones (EZs) could have made them electron donors and therefore reductive.

   The addition of protons in the experiment of Carell reducing the pH of water could have induced a transformation of dark protons at magnetic flux tube to ordinary protons. Dark protons bound to the amines would have

transformed to ordinary protons and inducing their chemical inactivity. Only for the amine formamide serving as a precursor of purine the dark proton-amine bound state was stable and remained chemically reactive since dark proton did not affect the properties of visible matter part of the compound. Symbiosis between dark and ordinary matter began. This view conforms also with the vision about the pairing of DNA/RNA and dark DNA/RNA formed by sequences of proton triplets representing DNA/RNA codons [L11]. DNA is indeed negatively charged and dark proton could neutralize it but allow it to remain chemically active.

B. Second possibility is suggested by the conjecture that prebiotic life evolved in the crust of Earth, perhaps in the underground oceans or regions related to volcanoes [K20, L9]. The content of oxygen of this environment could have been much lower than at the surface making it reductive: it would not be possible to even talk about atmosphere. But where did the metabolic energy come from? Could volcanic energy emitted as dark long wave photons with energies in the range of bio-photon energies help here? There are indeed a theories assuming that first life forms emerged from volcanoes. These problems are discussed in [K20, L9] from TGD viewpoint. Note that these two explanations do not exclude each other.

6.7 Could the replication of mirror DNA teach something about chiral selection?

I received a link to a very interesting popular article (see `http://tinyurl.com/zqgutdv`) from which I learned that short strands of mirror DNA and mirror RNA - known as aptamers - have been be produced commercially for decades - a total surprise to me. Aptamers bind to targets like proteins and block their activity and this ability can be utilized for medical purposes.

Now researchers at Tsinghua University of Beijing have been able to create a mirror variant of an enzyme - DNA polymeraze - catalyzing the transcription of mirror DNA to mirror RNA also replication of mirror DNA [I13]. What is needed are the DNA strand to be replicated or transcribed, the mirror DNA nucleotides, and short primer strand (see `http://tinyurl.com/j3o8cyx`)) since the DNA polymeraze starts to work only if the primer is present. This is like recalling a poem only after hearing the first few words.

The commonly used DNA polymerase containing about 600 amino-adics is too long to be built up as a right-handed version and researchers used a much shorter version: African swine fever virus having only 174 amino-acids. The replication turned out to be very slow. A primer of 12 nucleotides was extended to a strand of 18 nucleotides in about 4 hours: 3/2 nucleotides per hour. The extension to a strand of 56 nucleotides took 36 hours making 44/36= 11/9 nucleotides per hour. DNA and its mirror image co-existed peacefully in a solution. One explanation for the absence of mirror life is that the replication and transcription of mirror form was so slow that it lost the fight for survival. Second explanation is that the emergence of mirror forms of DNA polymerase and other enzymes was less probable.

Can one learn anything about this?

A. Chiral selection is one of the deep mysteries of biology. Amino-acids are left-handed and DNA and RNA double strands form a right-handed screw. One can assign handedness with individual DNA nucleotides and with DNA double strand but web sources speak only about the chirality of double strand. If the chirality of the DNA nucleotides were not fixed, it would have been very probably discovered long time ago as an additional bit doubling the number of DNA letters.

B. What could be the origin of the chirality selection? Second helicity could have been loser in the fight for survival and the above finding supports

this: fast ones eat the slow ones like in market economy. There must be however a breaking of mirror symmetry. Weak interactions break of mirror symmetry but the breaking is extremely small because the weak bosons mediating weak interaction are so massive that the length scale in which the breaking of mirror symmetry matters is of order 1/100 times proton size. This breaking is quite too small to explain chiral selection occurring in nano-scales: there is discrepancy of 8 orders of magnitude. The proposal has been that the breaking of mirror symmetry has been spontaneous and induced by a very small seed. As far as I know, no convincing candidate for the seed has been identified.

According to TGD inspired model chiral selection would be induced from that in dark matter sector identified in terms of phases of ordinary matter with non-standard value of Planck constant $h_{eff}/h = n$ [**?**, K37]. In living matter dark matter would reside at magnetic flux tubes and control ordinary matter. TGD predicts standard model couplings, in particular weak parity breaking. For $h_{eff}/h = n$ the scale below which weak bosons behave as massless particles implying large parity breaking is scaled up by n. Large parity breaking for dark matter becomes possible in even biological length scales for large enough h_{eff}.

The crucial finding is that the states of dark proton regarded as part of dark nuclear string can be mapped naturally to DNA, RNA, tRNA, and amino-acid molecules and that vertebrate genetic code can be reproduced naturally [K23]. This suggests that genetic code is realized at the level of dark nuclear physics and induces its chemical variant. More generally, biochemistry would be kind of shadow of dark matter physics. A model for dark proton sequences and their helical pairing is proposed and estimates for the parity conserving and breaking parts of Z^0 interaction potential are deduced.

6.7.1 Dark matter and chirality selection

In TGD framework the hierarchy of Planck constants suggests an explanation for the chirality selection.

A. In TGD Universe the new physics of quantum biology involves magnetic bodies and dark proton sequences as a representation of the genetic code at the level of dark nuclear physics. The crucial observation is that dark proton states provide representations for RNA, DNA, tRNA, and amino-acids [K23, K31] and there is also natural map between DNA and amino-acid type states giving rise to vertebrate genetic code. This looks like a miracle and I find still difficult to believe that it is true. A The extreme slowness of the wrong-handed DNA replication as compared to the ordinary replication means large breaking of parity symmetry. This is possible to understand in terms of weak interactions only if they are dark in DNA length scales so that weak bosons are effectively massless and weak interactions are as strong as electromagnetic interactions.

   This suggests that the replication of DNA and takes place at the level of dark proton sequencies - dark nuclear strings - serving as a dynamical template for the biological replication. Also transcription and translation would be induced by dark processes. Actually all biochemical processes could have as template the dynamics of molecular magnetic bodies and biochemistry would be kind of shadow of dark matter physics.

   If this is the case, then chiral selection would take place the selection at the level of dark nuclear strings and induce that the level of biochemistry. If dark and ordinary chiralities fit together like hand and glove. Dark matter at magnetic bodies could control the behavior of ordinary matter. By parity breaking the dark weak binding energy between members of proton pairs in the dark DNA strand consisting of a pair of helical dark proton strings is higher for the second helical chirality and would favour

this chirality. A very naïve thermodynamical estimate is that the ratio of the densities of two chiralities is proportional to the Boltzmann exponent $exp(-\Delta E_B/T)$. The transition to thermodynamical equilibrium can be however very slow so that thermodynamical argument need not make sense.

B. There is experimental support for dark proton sequences. Leif Holmlid and Berhard Kotzias [L18] (see `http://tinyurl.com/hxbvfc7`) have published an article about the superdense phase of hydrogen proposed to make possible to overcome the Coulomb wall making cold fusion impossible in the textbook Universe. In TGD superdense phase has interpretation as dark proton sequences at magnetic flux tubes with the Compton length of dark proton coded by $h_{eff}/h = n_{eff} \simeq 2^{11}$ to electron's Compton length [L6]. Remarkably, it is reported that the superdense hydrogen is super-conductor and super-fluid at room temperatures and even above: this is just what TGD predicts.
The dark protons in TGD inspired quantum biology (see `http://tinyurl.com/lwxdl7y`) should have much longer Compton length of the order of the distance between nucleotides in DNA sequences in order to serve as templates for chemical DNA. This gives a dark Compton length of order $\simeq 3.3$ Angstroms from the fact that there are 10 codons per 10 nm. This would give $n_{eff,p} \simeq 2^{18}$. The safest manner to estimate the dark binding energy is by scaling the binding energy about $E_B \simeq 7$ MeV per nucleon by $1/n_{eff,p}$ to give $E_{B,d} = E_B/n_{eff,p} = 28$ eV.

C. Further evidence for the importance of dark protons in biology comes from the recent finding of the group led by Thomas Carell related to the understanding the origins of life [I7] (see `http://tinyurl.com/z65kpyo`). For TGD inspired model see [L16], [**?**]. Carell *et al* have identified a mechanism leading to the generation of purines A and G, which besides pyrimidines A,T (U) are the basic building bricks of DNA and RNA. The crucial step is to make the solution involved slightly acidic by adding protons.
In TGD inspired quantum biology this suggest that the protons in the acidic water are dark and that the attachment of the dark protons to the amines of the amino-pyrimidine transforms them to ordinary protons and makes the amino-pyrimidine non-reactive. There would be however one exception: the amine which reacts further to give purines as a reaction product. In this case the proton would remain dark and the chemical properties of the amine would remain intact. This suggests that DNA nucleotides and DNA strands can attach to dark protons or are accompanied by them.

6.7.2 Model for the replication of DNA

One can consider a detailed model for the replication as induced by the addition of dark protons to dark proton sequence representing dark DNA strand. The added dark protons would be accompanied or attached with the DNA nucleotides as suggested by the work of Carell *et al*.

A. In the replication and transcription of DNA the basic step would be the addition of dark proton to an increasing dark proton sequence. The need for primer means that there must already exist a dark proton sequence. In the presence of prime the attractive dark nuclear binding energy of the added dark proton with the prime would make the dark fusion rate higher. The addition of dark protons could proceed like a dark nuclear chain reaction. It would be made possible by the dark nuclear binding energy per proton scaling like $1/h_{eff,p}$.
For the ordinary nuclei the binding energy per nucleon would be of the order of 7 MeV (note that charge independence of strong interactions holds in good approximation). The scaling down by $h_{eff}/h = 2^{18}$ would give $E_B \simeq 4$ eV, which corresponds to UV photon energy. Note that bio-

photons assumed to correspond dark photons with same energy have energies in visible and UV range.

B. Dark nuclear energy cannot explain parity breaking. The axial part of dark weak energy between dark protons belonging to dark strand and its conjugate and having nuclei acids and its conjugate as a chemical "shadow" must be also involved. Two values of h_{eff} are involved: $h_{eff,p}$ assignable to the flux tubes containing dark protons parallel to DNA strands and $h_{eff,W}$ assignable to the transversal flux tube connecting dark protons associated with different dark strands.
One of the assumptions of the TGD inspired model of cold fusion [L6, L18] is that the weak scale is scaled up from weak boson Compton length to about atomic length scale. This would require $h_{eff,W}/h = n_{eff,W}$ for weak bosons to be roughly

$$n_{eff,W} \simeq \frac{m_Z}{m_p} \times n_{eff,p} \simeq 91 \times n_{eff,p}$$

so that one would have $n_{eff,W} \simeq 2^{25}$. If this is the case weak interactions are of essentially same strength as em interaction below the scaled up Compton scale of order 3 Angstroms. This makes it possible to talk about classical Z^0 Coulomb potential and about spin dependent parity breaking Z^0 force. These two interaction energies sum up and this reduces the binding energy per proton in double strand for the other chirality.

C. The parity conserving Z^0 Coulomb interaction energy between two protons at different strands connected by a flux tube is given by the expression

$$\begin{aligned} & V_{PC}(r_{12}) = -kV(r_{12}) \ , \quad V(r_{12}) = \tfrac{\hbar}{r_{12}} \ , \\ & k = \alpha_Z Q_Z^2(p) \ , \qquad\qquad \alpha_Z = \tfrac{\alpha}{sin^2(\theta_W)cos^2(\theta_W)} \ , \quad Q_Z(p) = 1/4 - sin^2(\theta_W) \ . \end{aligned} \tag{6.2}$$

Here units $\hbar = 1$, $c = 1$ are used. r_{12} refers to the distance between dark protons at magnetic flux tubes assignable to DNA strands. Base pair thickness is about .34 nm and thickness of DNA double strand is about 2 nm. r_{12} could be between these two limits.

D. The spin dependent and parity non-conserving Z^0 interaction potential for Dirac spinors proportional to the gradient of the Z^0 Coulomb potential can be written as

$$V_{PNC} \quad = \quad \alpha_Z Q_Z^A(p) Q_Z^V(p) \gamma_5 V(r_{12}) \ . \tag{6.3}$$

Here $Q_Z^A = I_{3,A}/2 = 1/4$ is the axial weak charge of proton. The vectorial charge of proton is $Q_Z(p) = 1/4 - sin^2(\theta_W) \simeq 0.02$ so that it is much smaller than $Q_Z^A(p)$. Hence the axial force dominates by a factor $10^2/8 \sim 12.5$ for a given relative position. Usually the axial part becomes very small by symmetries as one estimates quantum averages but in the recent situation one cannot expect this since the positions of dark protons are in the first approximation fixed.

E. Using non-relativistic correspondence following from $\gamma_5 = \gamma_0\gamma_1\gamma_2\gamma_3$ and $(\gamma_5)^2 = -1$: this equation holds true also for $(\gamma^0\gamma^k p_k(m)$, and one has

$$\gamma_5 \to \frac{\overline{\sigma} \cdot p}{m_p} \ .$$

Here $\overline{\sigma}$ denotes Pauli sigma matrices expressible as $\gamma^0\gamma^i$). Using the replacement $p \leftrightarrow i\hbar_{eff,W}\nabla$ one can write V_{PNC} as the sum of the axial energies of the two protons

$$\begin{aligned} V_{s_1,s_2} &= V_{s_1} + V_{s_2} \ , \\ V_{s_i} &= \frac{\hbar_{eff,W}}{m_p}\overline{\sigma}_i \cdot \nabla_i V_{PC}(r_{12}) = (-1)^i \frac{k n_{eff,W}\hbar}{m_p}\hbar \frac{\overline{\sigma}_i \cdot \overline{r}_{12}}{r_{12}^2} \ . \ i = 1,2 \ . \end{aligned} \tag{6.4}$$

The parity breaking part of Z^0 force is proportional to $n_{eff,W}$ from the expression of momentum operator in terms of gradient operator so that dark matter physics makes itself visible and increases further the magnitude of parity breaking. The potential energy changes sign in reflection $\overline{r}_{12} \to -\overline{r}_{12}$. This gives

$$\begin{aligned} V_{s_1,s_2} &= -\frac{\alpha_Z}{4}(\frac{1}{4} - sin^2(\theta_W))\frac{n_{eff,W}\hbar}{m_p r_{12}}\frac{(\overline{\sigma}_1 - \overline{\sigma}_2)\cdot \overline{r}_{12}}{r_{12}}\frac{\hbar}{r_{12}} \\ &= \frac{1}{4}\frac{1}{(\frac{1}{4} - sin^2(\theta_W)}\frac{n_{eff,W}\hbar}{m_p r_{12}}\frac{(\overline{\sigma}_1 - \overline{\sigma}_2)\cdot \overline{r}_{12}}{r_{12}} V_{PC}(r_{12}) \ . \end{aligned} \tag{6.5}$$

F. For the vectorial part one has

$$V_{PC} = -\alpha_Z(\frac{1}{4} - sin^2(\theta_W))^2 V(r_{12}) \ . \tag{6.6}$$

The order of magnitude is about $V_Z = .16/x$ eV.

G. The condition that r_{12} corresponds to dark Compton length of proton implies in the first approximation $\frac{n_{eff,p}}{m_p r_{12}} = 1$ so that $n_{eff,W}$ proportionality gives factor $m_Z/m_p \simeq 91$. The order of magnitude parity breaking potential is the value potential at distance in the range $r_{12} \in [3.4, 2]$ nm. Let us expres the horizontal distance between the paired dark protons as $r_{12} = x$ Angstroms. This gives for the axial part

$$\begin{aligned} V_{s_1,s_2} &= \frac{1}{4}\frac{1}{(\frac{1}{4} - sin^2(\theta_W)}\frac{m_Z}{m_p}(\overline{\sigma}_1 - \overline{\sigma}_2)\cdot\frac{\overline{r}_{12}}{r_{12}} V_{PC}(r_{12}) \\ &\simeq .5 \times 10^2 \times 91 \times \frac{V_{PC}(r_{12})}{x} \times (\overline{\sigma}_1 - \overline{\sigma}_2)\cdot\frac{\overline{r}_{12}}{r_{12}} \ . \end{aligned} \tag{6.7}$$

The order or magnitude for the axial part is roughly $4550/x$ times larger than for the vectorial part. V_{PNC} is proportional to $1/x^2$ and V_{PC} to $1/x$. The condition that the states are spin eigenstates requires that spin quantization axes must be chosen along the flux tube connecting the dark protons. This is rather natural choice.
This would give for the axial part order of magnitude $V_{PNC} \sim 728/x^2$. For 2 nm distance one would obtain $V_{PNC} \sim 1.82$ eV. For 1 nm distance one would have $x = 10$ and this would give $V_{PNC} \simeq 7.28$ eV. For this value $V_{PC} \simeq 16$ meV, which is of same order of magnitude as thermal energy $kT/2$ at room temperature.

H. The process of adding dark protons to the increasing DNA sequence must be possible irrespectively of the direction of spin. The spin eigenvalue in the direction of the horizontal axis connecting the members of dark proton pair is assumed to be opposite for the members of the dark proton pairs of dark double strand. This assumption comes from the model of the

dark genetic code. This demands that V_{NPC} is considerably smaller than strong binding energy E_B. For 1 nm distance one has $V_{PNC} \simeq 7.28$ eV considerably smaller than $E_B \simeq 28$ eV.

I. What is the relation of the fermionic chirality to the geometric chirality? The reflection for dark protons induces the reflection of the entire helix turning also its direction. The reflection permutes the dark protons of each pair since their positions are related by reflection in the plane orthogonal to z-axis $(x_2, y_2) = (-x_1, -y_1)$. One has $(x_1, y_1, z) \leftrightarrow (x_2, y_2, -z)$. A further rotation of π in say (x, z)-plane around say y-axis is symmetry and gives $(x_2, y_2, -z) \rightarrow (-x_2, y_2, z) = (x_1, -y_1, z)$. Hence the net effect is $(x_1, y_1, z) \rightarrow (x_1, -y_1, z)$ and DNA strand with an opposite screw direction is generated.

The model of dark genetic code motivates the assumption that the dark protons of the pair are spin eigenstates for the spin projection along the axis connecting the members of the pair. The direction of the spin quantization axis changes in reflection from that given by (x_1, y_1) to that given by $(x_1, -y_1)$ so that the states are not anymore eigenstates of the spin projection along this axis. Thus the fermionic chirality indeed correlates with the chirality of double strand and the two chiralities are in physically different position.

What happens at the level of classical fields? Kähler magnetic field transforms like angular momentum in reflections and rotations as is easy to see from its expression in terms of vector potential. Hence it does not change its direction in reflection but changes its direction in the rotation. Hence the magnetic flux along flux tube changes to opposite in the reflection. This also affects the physics and induces effects at the level of dark strong interactions. The magnetic energy is of form $s \cdot B$ and vanishes classically. Quantum mechanically it does not vanish since s is operator and one can wonder what this implies physically.

6.7.3 Differences between standard model and TGD based description

The above estimate relies on standard model, which is quantum field theory in Minkowski space, and one can wonder what new elements TGD brings in. I do not try to estimate the effects in TGD framework but just list the differences.

A. In TGD framework space-time is 4-surface in $M^4 \times CP_2$ and this description must be replaced with a description using 8-D embedding spinors. At space-time level massive M^4 Dirac equation $p_k \gamma^k \Psi = m\Psi$ is replaced by 8-D chiral symmetry implying separate conservation of quark and lepton numbers with the analog of massless Dirac equation for the Kähler-Dirac gamma matrices, which are superpositions of M^4 and CP_2 gamma matrices. K-D gamma matrices are contractions of canonical momentum current densities of Kähler action with the embedding space gamma matrices. If the action is volume term, one obtains induced gamma matrices. The twistorialization of TGD by replacing the embedding space with the product of twistor spaces of M^4 and CP_2 and lifting space-time surfaces to their twistor spaces with induced twistor structure leads to the addition of volume term to Kähler action [K21]. This term corresponds to cosmological constant and is extremely small in the recent cosmology.

B. One can decompose K-D gamma matrices to their M^4 and CP_2 parts: $\Gamma^\alpha = \Gamma^\alpha_{M^4} + \Gamma^\alpha_{CP_2}$ and write the K-D equation as $\Gamma^\alpha_{M^4} D_\alpha \Psi = -\Gamma^\alpha_{CP_2} \Psi$. The presence of $\Gamma^\alpha_{CP_2}$ parts breaks conservation of M^4 chirality and serves as a signal for massivation. This operator is kind of mass operator acting non-trivial in electroweak spin degrees of freedom assignable to CP_2 and the action of its square is analogous to the action of mass squared operator.

The understanding of particle massivation at this level does not seem however possible and the proper approach relies of p-adic thermodynamics for super-Virasoro representations for which ground states are characterized by the modes of embedding space spinors which are massless in 8-D sense and are eigenstates of M^4 mass squared operator with eigenvalues determined by CP_2 spinor Laplacian [K27]. Its action on M^4 chirality is same as action of mass in massive Dirac equation in M^4.

C. In the case of M^4 Dirac equation the multiplication of massive Dirac equation with γ_5 using anti-commutativity of γ_5 and γ_k gives $\gamma^k p_k \gamma_5 \Psi = -m\gamma_5\Psi$ instead of$p_k\gamma^k\Psi = m\Psi$. TGD framework γ_5 anti-commutes with $\Gamma^\alpha_{M^4}$ but commutes with $\Gamma^\alpha_{CP_2}$ so that also now one has similar equation $\Gamma^\alpha_{M^4} D_\alpha \Psi = +\Gamma^\alpha_{CP_2}\Psi$.

6.8 Is dark DNA dark also in TGD sense?

I encountered a highly interesting article about "dark DNA" hitherto found in the genome of gerbils and birds, for instance in the genome of of the sand rat living in deserts (see `http://tinyurl.com/y8zdgnej`). The gene called Pdxl related to the production of insulin seems to be missing as also 87 other genes surrounding it! What makes this so strange that the animal cannot survive without these genes! Products that the instructions from the missing genes would create are however detected!

According to the ordinary genetic, these genes cannot be missing but should be hidden, hence the attribute "dark" in analogy with dark matter. The dark genes contain A lot of G and C molecules and this kind of genes are not easy to detect: this might explain why the genes remain undetected.

A further interesting observation is that one part of the sand rat genome has many more mutations than found in other rodent genomes and is also GC rich. Could the mutated genes do the job of the original genes? Missing DNA are found in birds too. For instance, the gene for leptin - a hormone regulating energy balance - seems to be missing.

The finding is extremely interesting from TGD view point, where dark DNA has very concrete meaning. Dark matter at magnetic flux tubes is what makes matter living in TGD Universe. Dark variants of particles have non-standard value $h_{eff} = n \times h$ of Planck constant making possible macroscopic quantum coherence among other things. Dark matter would serve as template for ordinary matter in living systems and biochemistry could be kind of shadow of the dynamics of dark matter. What I call dark DNA would correspond to dark analogs of atomic nuclei realized as dark proton sequences with entangled proton triplet representing DNA codon. The model predicts correctly the numbers of DNA codons coding for given amino-acid in the case of vertebrate genetic code and therefore I am forced to take it very seriously [L11, L7] (see `http://tinyurl.com/jgfjlbe` and `http://tinyurl.com/ydb2tfy8`).

The chemical DNA strands would be attached to parallel dark DNA strands and the chemical representation would not be always perfect: this could explain variations of DNA. This picture inspires also the proposal that evolution is not a passive process occurring via random mutations with survivors selected by the evolutionary pressures. Rather, living system would have R&D lab as one particular department. Various variants of DNA would be tested by transcribing dark DNA to ordinary mRNA in turn translated to amino-acids to see whether the outcome survives. This experimentaiton might be possible in much shorted time scale than that based on random mutations. Also immune system, which is rapidly changing, could involve this kind of R&D lab.

Also dark mRNA and amino-acids could be present but dark DNA is the fundamental information carrying unit and it would be natural to transcribe it to ordinary mRNA. Of course, also dark mRNA could be produced and translated to amino-acids and even dark amino-acids could be transformed to

ordinary ones. This would however require additional machinery.
What is remarkable is that the missing DNA is indeed associated with DNA sequences with exceptionally high mutation rate. Maybe R&D lab is there! If so, the dark DNA would be dark also in TGD sense! Why GC richness should relate to this, is an interesting question.

7 The analogs of CKM mixing and neutrino oscillations for particle and its dark variants

In TGD Universe dark matter in TGD sense corresponds to $h_{eff}/h_0 = n$, $h = 6h_0$ is a good guess [L15, L32, L23] phases of ordinary matter associated with magnetic flux tubes. These flux tubes would be n-sheeted covering spaces, and n would correspond to the dimension of the extension of rationals in which Galois group acts. The evidence for this interpretation of dark matter is accumulating. I have already earlier discussed [L35] one of the latest anomalies - so called 21-cm anomaly. This finding motivates a more detailed model for the interaction between different levels of dark matter hierarchy and in the sequel I will propose this kind of model.

7.1 21-cm anomaly as a motivation for the model of the interaction between different levels of h_{eff} hierarchy

Sabine Hossenfelder (see `http://tinyurl.com/y7h5ys2r`) told about the article [**?**] discussing the possible interpretation (see `http://tinyurl.com/yasgfgq8`) of so called 21-cm anomaly associated with the hyperfine transition of hydrogen atom and observed by EDGES collaboration [**?**].
The EDGES Collaboration has recently reported the detection of a stronger-than-expected absorption feature in the global 21-cm spectrum, centered at a frequency corresponding to a redshift of $z \sim 17$. *This observation has been interpreted as evidence that the gas was cooled during this era as a result of scattering with dark matter. In this study, we explore this possibility, applying constraints from the cosmic microwave background, light element abundances, Supernova 1987A, and a variety of laboratory experiments. After taking these constraints into account, we find that the vast majority of the parameter space capable of generating the observed 21-cm signal is ruled out. The only range of models that remains viable is that in which a small fraction,* $\sim 0.3 - 2$ *per cent, of the dark matter consists of particles with a mass of* $\sim$ *10-80 MeV and which couple to the photon through a small electric charge,* $\epsilon \sim 10^{-6} - 10^{-4}$. *Furthermore, in order to avoid being overproduced in the early universe, such models must be supplemented with an additional depletion mechanism, such as annihilations through a* $L_\mu - L_\tau$ *gauge boson or annihilations to a pair of rapidly decaying hidden sector scalars.*
What has been found is an unexpectedly strong absorption feature in 21-cm spectrum: the redshift is about $z = \Delta f/f \simeq v/c \simeq 17$, which from Hubble law $v = HD$ corresponds to a distance $D \sim 2.3 \times 10^{11}$ ly. Dark matter interpretation would be in terms of scattering of the baryons of gas from dark matter at lower temperature. The anomalous absorption of 21 cm line could be explained with the cooling of gas caused by the flow of energy to a colder medium consisting of dark matter. If I understood correctly, this would generate a temperature difference between background radiation and gas and consequent energy flow to gas inducing the anomaly.
The article excludes large amount of parameter space able to generate the observed signal. The idea is that the interaction of baryons of the gas with dark matter. The interaction would be mediated by photons. The small em charge of the new particle is needed to make it "dark enough". My conviction is that tinkering with the quantization of electromagnetic charge is only a

symptom about how desperate the situation is concerning interpretation of dark matter in terms of some exotic particles is. Something genuinely new physics is involved and the old recipes of particle physicists do not work.
In TGD framework the dark matter at lower temperature would be $h_{eff}/h = n$ phases of ordinary matter residing at magnetic flux tubes. This picture follows from what I call adelic physics [L28, L29]. This kind of energy transfer between ordinary and dark matter is a general signature of dark matter in TGD sense, and there are indications from some experiments relating to primordial life forms for this kind of energy flow in lab scale [L25] (see `http://tinyurl.com/yassnhzb`) .
The ordinary photon line appearing in the Feynman diagram describing the exchange of photon would be replaced with a photon line containing a vertex in which the photon transforms to dark photon. The coupling in the vertex - call it m^2 - would have dimensions of mass squared. This would transform the coupling e^2 associated with the photon exchange effectively to e^2m^2/p^2, where p^2 is photon's virtual mass squared. The slow rate for the transformation of ordinary photon to dark photon could be see as an effective reduction of electromagnetic charge for dark matter particle from its quantized value.
Remark: In biological systems dark cyclotron photons would transform to ordinary photons and would be interpreted as bio-photons with energies in visible and UV.
The importance of this finding is that it supports the view about dark matter as ordinary particles in a new phase. There are electromagnetic interactions but the transformation of ordinary photons to dark photons slows down the process and makes these exotic phases effectively dark.
The above picture motivates the attempt to construct a model for the mixing of not only ordinary photons but any particle with its dark variants with various values of $h_{eff}/h_0 = n$ by generalizing the formalism developed for the mixing of neutrinos and their oscillations. Also now oscillations are predicted and they could serve as a test for TGD based model of dark matter. Also the description at the level of Feynman diagrams is briefly summarize. This picture in principle allows the modelling of the energy transfer between ordinary and dark sectors.

7.2 Mixing and oscillations of dark photons

In TGD framework dark matter corresponds to phases of ordinary matter with non-standard value of Planck constant $h_{eff}/h_0 = n$ [**?**]. Here $h = 6h_0$ is a good guess [L15, L32]. It has been assumed that only the reaction vertices would be between particles with same value of $h_{eff}/h = n$, whereas the transformation changing the value of n during propagation is assumed to be possible. For instance, biophotons would be ordinary photons emerging when dark photons transform to ordinary photons. Therefore the mixing of ordinary particles with their dark variants can be considered.
This allows to deduce the general form of propagator which is simple for the mixed mass squared eigenstates in terms of mass squared matrix. There is however a problem associated with photons. They must have extremely small mass although p-adic mass calculations suggests that photon has very small p-adic thermal mass squared [K27]. Are they exactly massless and what conditions masslessness poses on mixing? It turns out that the eigenstates of n most naturally have same mass and the mixing makes other state massless so that ordinary photon would not have minimal value of n - presumably $n = 6$ - during propagation but in absorption the state would be projected to $n = 6$.

7.2.1 Mixing and oscillations of ordinary and dark particles

Could the analog of CKM mixing take place for ordinary and dark photons? Is the analog of neutrino oscillations possible for photon and dark photon? Could these oscillations occur also for neutrinos besides ordinary neutrino oscillations? The model for the analog of ordinary-dark oscillations could be essentially the same as that for neutrino oscillations (see `http://tinyurl.com/oov344k`) and consist of the following pieces.

In the case of neutrino mixing involving 3 neutrinos the calculation gives the result given in Wikipedia article (see `http://tinyurl.com/oov344k`). Since the formula does not depend on the number of flavors, it easily generalize to the case that one has arbitrary number N of values of $h_{eff}/h_0 = n$, which mix. The analog of CKM matrix describing the mixing of neutrinos, the mass squared differences, and the distance L between source and receiver determines the oscillation dynamics and generalizes as such to the description of mixing and oscillation of particles with different values of h_{eff}. For N values of n including $n = n_0 = 6$ assigned with ordinary matter, the analog of CKM matrix is $N \times N$ unitary matrix.

This matrix, call it C, is completely determined by the mass squared matrix with non-diagonal components. Mass squared eigenstates are superpositions of states with well-defined value of n_{eff} having the rows of this matrix as coefficients. Therefore the non-diagonal component of mass squared matrix, to called K^2, describing the mixing of different values of n determines both mixing and oscillations.

A non-trivial modification of the formula for the neutrino oscillations comes from the fact that plane wave factor s $exp([iE_i - p)L/\hbar_{eff}(\alpha)]$ depend on the value of $\hbar_{eff}(\alpha) = n^\alpha \hbar_0$.

The following model applies to any particle species.

A. The mixing of ordinary and dark particles would be an analog of CKM mixing for quarks and leptons. Now ordinary particleand its dark variants would mix with each other. Note that given value of n can correspond to several extensions of rationals. In principle also this degeneracy must be also be taken into account.

B. The analog of neutrino oscillations would mean that ordinary particles disappear from beam by transforming to dark particles and can be regenerated. The formalism for neutrino oscillations seems to generalize almost as such to ordinary-dark particle oscillations. Oscillations could be used as test for TGD view about dark matter.

C. In the initial and final state the particle would be either ordinary or dark with some value of n being analogous to a flavor eigenstate for neutrino. These states are not eigenstates of mass and energy and it convenient to express them as mass squared eigenstates related by CKM matrix to eigenstates of n. During propagation states can be regarded as superpositions of eigenstates of mass squared operator M^2. This hermitian operator is sum of ordinary mass squared operators for the sectors labelled by n but there are non-diagonal term is causing the mixing.

D. One has on mass shall condition in momentum space which can be written as

$$(p^2 - M^2_{op})\Psi = 0 \ . \tag{7.1}$$

p^2 represents four momentum square in various sectors labelled by n^α and can be regarded as direct sum $p^2 = \oplus p^2(n^\alpha)$.

For given value of 3-momentum the situation is identical for a system consisting of N coupled harmonic oscillators and the situation is mathematically equivalent to the diagonalization of the system by finding the eigenmodes and eigenfrequencies.

E. Mass squared operator is direct sum

$$M^2_{op} = \oplus_{n^\alpha} m^2(n^\alpha) + K^2 \quad . \tag{7.2}$$

$K^2_{\alpha\beta}$ is non-diagonal coupling different sectors n^α and thus mixing of partial waves with different values of n. The assumption has been that $m^2(n^\alpha)$ does not depend on n^α. The presence of the non-diagonal mixing term $K^2_{\alpha\beta}$ causes mass squared eigenstates to have different masses.
M^2_{op} would have for $N = 2$ (ordinary particle and its dark variant with single value of n) the form

$$M^2_{op} = \left[\begin{array}{cc} m^2 & K^2 \\ \overline{K^2} & m^2 \end{array} \right] \quad . \tag{7.3}$$

Note that one K^2 can be also complex.

F. In this form the value of $\hbar_{eff}$ is not visible at all in p^2. At the space-time level $p^2 = E^2 - p_3^2$ must be however expressed as d'Alembert operator via the usual rules $E \to i\hbar_{eff}\partial_t$ and $p \to i\hbar_{eff}\partial_z$ so that one has

$$\begin{aligned} &(-\Box - M^2_{op})\Psi = 0 \ , \quad \Box = \oplus_\alpha \Box_{n^\alpha} \ , \\ &\Box_n = n^2\hbar_0^2\Box \ , \qquad\qquad \Box = \partial_t^2 - \partial_x^2 - \partial_y^2 - \partial_z^2 \ . \end{aligned} \tag{7.4}$$

Plane wave solutions are of form $exp(i(E-p)z/n\hbar_0)$ and differ by a scaling of the argument. This applies also to general solutions. One has fractally scaled variants of the solution and K^2 matrix defines coupling between them.

G. This formulation generalizes trivially to general 4-D case solutions and to general solutions of d'Alembert type field equations. In QFT language one has an analog of N-component scalar field for which mass squared matrix M^2_{op} containing quadratic couplings between field components. The generalization seems obvious also for more general fields such as spinor fields and gauge fields. For instance, for gauge fields one would have N copies of gauge fields with non-diagonal couplings. The invariants $F^{\mu\nu}_{n^\alpha}F_{n^\beta,\mu\nu}$ are suggestive for gauge invariant couplings.
The new element is that these N fields have different value of h_{eff} and the solutions are fractally scaled variants of each other.

H. The eigenstates $|i\rangle$ of the d'Alembert type operator are eigenstates of M^2_{op} and eigenvalues are mass squared eigenvalues m_i^2. $|i\rangle$ are superpositions states with fixed value of n with coefficients, which are the components of the analog C of CKM matrix:

$$|i, x\rangle = C_{i\alpha} e^{i\frac{p_4\cdot x}{n^\alpha\hbar_0}} |n^\alpha\rangle \quad . \tag{7.5}$$

Here one has summation of the repeated index α appearing as both upper and lower index. This holds quite generally for Fourier basis. Therefore the non-diagonal part of mass squared operator determines the C as a prediction.

The S-matrix for the effectively 2-D system considered is needed to deduce oscillation probabilities. One has a beam of particles with momentum p independent of value of n travelling distance L along line $z = t$. The mass parameter $m^2(n)$ is independent of n.

A. To deduce S-matrix start from the expression of the identity operator Id as

$$Id = |i, t = 0\rangle\langle i, t = 0|$$

acting at the end $z = 0$. The states $|i, t = 0\rangle$ correspond to the starting point $z = 0$ of propagation. The notation $|n^\alpha, t = 0\rangle = |n^\alpha\rangle$ will be used. Time evolution shifts the states $|i, t = 0\rangle = C_{i\alpha}|n^\alpha\rangle$ to $t = z = L$) by the above time evolution.

B. S-matrix is obtained by translating the states $|i, t = 0\rangle$ appearing in the identity operator to $(t = L, z = L)$.

$$S = \sum_i |i, t = L\rangle\langle i, t = 0| \ . \tag{7.6}$$

C. One can find the expression of S in the basis $|i, t = L\rangle$ by writing $|i, t = L\rangle$ as a superposition of states $|n^\alpha\rangle$:

$$\begin{aligned} &|i, t = 0\rangle = C_{i\alpha}|n^\alpha\rangle \quad \rightarrow \qquad\qquad |i, t = L\rangle = C_{i\alpha}U^i_\alpha|n^\alpha\rangle \ , \\ &U^i_\alpha = e^{i\frac{(E_i-p)L}{n^\alpha\hbar_0}} \ , \qquad E_i = \sqrt{p^2 + m_i^2} \ . \end{aligned} \tag{7.7}$$

Using this formula one can express S using basis $|n^\alpha|$.

$$\begin{aligned} S &= S_{\alpha\beta}|n^\alpha\rangle\langle n^\beta| \ , \\ S_{\alpha\beta} &= \overline{C}^i_\alpha C_{i\beta}U^i_\alpha \ . \end{aligned} \tag{7.8}$$

Here the summation convention for the repeated index i applies.

What are needed are the oscillation probabilities $P_{\alpha\beta}$.

A. The probabilities that an eigenstate $|n^\alpha\rangle$ transforms to eigenstate $|n^\beta\rangle$ during the travel are given by

$$\begin{aligned} &P_{\alpha\beta} = |S_{\alpha\beta}|^2 = Y_{\alpha\beta ij}U^{ij}_{\alpha\beta} \ , \qquad\qquad Y_{\alpha\beta ij} = \overline{C}_{i\alpha}C_{i\beta}C_{j\alpha}\overline{C}_{j\beta} \\ &U^{ij}_{\alpha\beta} = U^i_\alpha\overline{U^j_\beta} = cos(X^{ij}_{\alpha\beta}) + isin(X^{ij}_{\alpha\beta}) \ , \quad X^{ij}_{\alpha\beta} = \tfrac{(E_i-p)L}{n^\alpha\hbar_0} - \tfrac{(E_j-p)L}{n^\beta\hbar_0} \ . \end{aligned} \tag{7.9}$$

B. One can decompose $P_{\alpha\beta}$ as

$$P_{\alpha\beta} = Re[Y_{\alpha\beta ij}]cos(X^{ij}_{\alpha\beta}) - Im[Y_{\alpha\beta ij}]sin(X^{ij}_{\alpha\beta}) \ , \tag{7.10}$$

and apply trigonometric formula $cos(2x) = 1 - 2sin^2(x)$, and decompose the summation to indices to 3 groups with $i < j$, $j < i$ and $i = j$ to get

$$P_{\alpha\beta} = \delta_{\alpha\beta} - 4\sum_{i<j} Re[Y_{\alpha\beta ij}]sin^2(\frac{X^{ij}_{\alpha\beta}}{2}) - 2\sum_{i<j} Im[Y_{\alpha\beta ij}]sin(X^{ij}_{\alpha\beta}) \tag{7.11}$$

Note that $\sum_\beta P_{\alpha\beta} = 1$ holds true since in the summation second term vanishes due to unitary condition $U^\dagger U = 1$ and $i > j$ condition in the formula.

C. In the completely relativistic situation $p >> m_i$ one can make the analog of non-relativistic approximation as $E_i = p + m_i^2/2p$. In this case one has

$$X^{ij}_{\alpha\beta} = \frac{(E_i - p)L}{n^\alpha\hbar_0} - \frac{(E_j - p)L}{n^\beta\hbar_0} \simeq \frac{m_i^2 L}{pn^\alpha\hbar_0} - \frac{m_j^2 L}{pn^\beta\hbar_0} \ . \tag{7.12}$$

D. For given 3-momentum p $P_{\alpha\beta}$ is a sum over $N \times (N-1)$ periodic functions of L with periods

$$\lambda^{ij}_{\alpha\beta} = \frac{2\pi}{X^{ij}_{\alpha\beta}} \quad . \tag{7.13}$$

E. At the limit of large L the trigonometric factors oscillate rapidly and in the averaging over sources region. The term proportional to $sin(x)$ gives zero whereas $sin^2(x)$ gives average $1/2$. The probabilities for various transitions induced by the oscillations depend on the analog of CKM matrix only. If the distance L is very large and the dependence on the mass squared differences and distance disappears in the averaging over the source region and one obtains

$$P_{\alpha\beta} = \delta_{\alpha\beta} - 2Re[Y_{\alpha\beta ij}] \quad . \tag{7.14}$$

Some general comments are in order.

A. The oscillation is detectable if the size of the non-diagonal part K^2 of the mass matrix is large enough as compared to the diagonal part. It is not clear whether this condition holds true for say fermions. The absence of tachyons requires that the value of m^2 (no dependence on n) is positive. m^2 could be interpreted as thermal mass squared in terms of p-adic mass calculations [K33, K27]. In the case of massless particles the mixing during propagation can however make the mass arbitrarily small as will be found.

B. What can be measured is the diagonal probability P_{11}, where $\alpha = 1$ corresponds to $h_{eff} = h$. The formula reduces to that for neutrino oscillations or its generalization to N flavors since $h_{eff} = h$ holds true now:

$$X^{ij}_{11} = \frac{(E_i - p)L}{\hbar} - \frac{(E_j - p)L}{\hbar} \simeq \frac{(m_i^2 - m_j^2)L}{p\hbar} \quad . \tag{7.15}$$

Remark: The part of P_{11} proportional to sine function has sine opposite to that in the formula of Wikipedia article (see `http://tinyurl.com/oov344k`): the reason is that the definition of $Y_{\alpha\beta ij}$ used here is complex conjugate of that used in Wikipedia formula.

C. Mass squared matrix and mixing matrix are not uniquely determined by the mass squared eigenvalues. Any unitary transform $M_D^2 \to UM_D^2U^\dagger$ of the mass matrix M_D^2 has the same eigenvalues. If the states with well-defined h_{eff} have the same mass in absence of mixing, $UM_D^2U^\dagger$ must have diagonal part equal to m^2Id.

This gives N conditions on U in both real and complex case. The conditions are however not dependent since the trace of M_D^2 equal to Nm^2 is preserved in the transformation so that there are only $N-1$ conditions in both real and complex case.

Since the number of the independent elements of a unitary matrix with unit determinant is $N^2 - 1$, this leaves in complex case $(N-1)^2$ parameter set of mass matrices with the same eigenvalues. Orthogonal matrix has $(N-1)N/2$ independent elements so that one has $(N-2)(N-1)/2$ parameters in the real case. For $N = 2$ complex case one has 1-parameter set of solutions corresponding to the phase of K^2, in the real $N = 2$ case one has two solutions corresponding to two signs for K^2. For $N = 3$ one has 4 parameters in complex case and 1 parameter in real case.

7.2.2 Mass squared matrix for photons

What can one say about mass squared matrix for photons? Consider a situation in which only two photons are mixed.

A. The most general form of mass matrix is in the case of single value of n given by $M^2_{op} = [m^2, K^2; \overline{K^2}, m^2]$. Note that the diagonal element is assumed to be nonvanishing: this allows to avoid tachyonic mass squared eigenstate. The eigen valuels of M^2_{op} are given by

$$M^2_{\pm} = m^2 \pm |K|^2 \quad . \tag{7.16}$$

B. The condition $M^2_- \geq 0$ gives $m^2 \geq |K|^2$. For the general mass squared matrix $M^2_{op} = [m^2_1, K^2; \overline{K^2}, m^2_2]$ the condition reads $m_1 m_2 \geq |K|^2$. If m_1 is very small, m_2 must be large in the scale defined by $|K|$.
One can argue that this form of mass squared matrix is the only reasonable option. If $n = 6$ photon is massless one obtains photons with masses $m^2 = \pm K^2$ and tachyonic photon is physically very problematic. It must be remembered that fort wistor lift of TGD all particles are massless in 8-D sense and can be massive in 4-D sense. Thereforethe assumption that "free" photon is massive need not lead to problems.

C. The mass of what we identify as ordinary photon and identified now as a mixed photon with lowest mass is extremely small: the recent upper bound is 7×10^{17} eV, which corresponds to Compton length of 10^{11} meters, which is of the order one astronomical unit AU: this probably relates to the measurement method. Photons thus behave like massless particles in the scale of Sun-Earth system. Therefore the approximation would $m^2 = |K|^2$ is excellent. The masses would be $M^2_- = 0$ and $M^2_+ = 2m^2$.

Dark photons in TGD sense play a key role in TGD inspired model of living matter. Bio-photons would result in the transformation of dark photons to ordinary photons. Mass squared eigenstates of photons have mass spectrum and a natural question is whether dark photon mass relevant to biology corresponds to a Compton length scale relevant to biology. In p-adic physics Compton lengths correspond to p-adic length scales which by p-adic length scale hypothesis correspond to primes $p \simeq 2^k$ near power of 2 (slightly below it).
Mersenne primes and their Gaussian analogs are especially interesting physically and in the length scale range 10 nm (neural membrane thickness) and 2.5 μ (size scale of nucleus) there are as many as 4 Gaussian Mersennes $M_{G,k} = (1+i)^k - 1$ corresponding to $k \in \{151, 157, 163, 167\}$. Could the p-adic mass scales $m/m_e = 2^{(k-127)/2}$ associated with these length scales be especially important in biology. More generally all p-adic mass scales assignable to these two kinds of Mersenne primes could be important as mass scales of mixed photons.

7.2.3 Could the mixing with dark photons provide and additional contribution to particle masses?

p-Adic thermodynamics [K27] provides an excellent description of particle massivation in the fermionic sector. It assumes only p-adic thermodynamics and superconformal invariance with partition functions determined by it, p-adic length scale hypothesis, and canonical identification $x = \sum x_n p^n \to \sum x_n p^{-n}$ mapping p-adic thermodynamical mass squared expectations to their real counterparts.
This need not however be the entire story. It is not clear whether one can really understand most of the hadron mass in this manner and whether gauge boson masses involving in the usual approach Higgs mechanism can be completely understood in this manner. Therefore one can ask whether the mixing of particles with their dark variants could contribute to the particle masses. In case of gauge bosons this contribution could be significant.

7.2.4 Description of ordinary-dark scattering diagrams

One would like also to develop a model for the scattering of ordinary and dark particles via exchange of ordinary photons transforming to dark photons or vice versa. Here one must be satisfied to phenomenological description although it is clear that there are non-trivial issues related to the gauge invariance in presence of massivation. The general TGD picture strongly suggests that these problems can be solved. In twistor lift of TGD particles become massless in 8-D sense and can be massive in 4-D sense.
The simplest assumption is that the massless photon propagator $D = P/p^2 - i\epsilon$, where P is a projector to the space of physical polarizations, is replaced with matrix propagator

$$D = [\frac{P}{p^2 Id - M^2(op)}]_{ij} = \frac{P}{p^2} \sum_{n \geq 0} [\frac{M^2(op)}{p^2}]^n_{ij} \quad . \tag{7.17}$$

For the mass squared eigenstates this gives diagonal matrix with poles corresponding to mass squared eigenvalues. What looks problematic is that the projector P for massive states projects to a 3-D space of polarization and for massless states to 2-D space of polarization. If also ordinary photon has very small mass as p-adic mass calculations strongly suggest, also it has longitudinal polarization and all projectors are 3-D.
The reaction vertices are possible only between particles with same value of n so that the propagator must be replaced in this basis by $C^\dagger DC$, where C is the analog of CKM mixing matrix mediating transition to mass eigenstates.

8 TGD Inspired View About Blackholes And Hawking Radiation

The most recent revelation of Hawking was in Hawking radiation conference held in KTH Royal Institute of Technology in Stockholm. The title of the posting of Bee (see `http://tinyurl.com/yakcmrza`) telling about what might have been revealed is "Hawking proposes new idea for how information might escape from black holes". Also Lubos (see `http://tinyurl.com/ydg78w92`) has - a rather aggressive - blog post about the talk. A collaboration of Hawking, Andrew Strominger and Malcom Perry is behind the claim and the work should be published within few months.
This inspired a fresh discussion of the notions of blackhole and Hawking radiation in TGD framework. The intention is to demonstrate that a pseudo problem following from the failure of General Relativity below black hole horizon is in question. There are several new elements involved but concerning black holes the most relevant new element is the assignment of Euclidian space-time regions as lines of generalized Feynman diagrams implying that also blackhole interiors correspond to this kind of regions. Negentropy Maximization Principle is also an important element and predicts that number theoretically defined black hole negentropy can only increase. The real surprise was that the temperature of the variant of Hawking radiation at the flux tubes of proton Sun system is room temperature! Could TGD variant of Hawking radiation be a key player in quantum biology?

8.1 Is Information Lost Or Not In Blackhole Collapse?

The basic problem is that classically the collapse to blackhole seems to destroy all information about the matter collapsing to the blackhole. The outcome is just infinitely dense mass point. There is also a theorem of classical GRT

stating that blackhole has no hair: blackhole is characterized only by few conserved charges.

Hawking has predicted that blackhole loses its mass by generating radiation, which looks like thermal. As blackhole radiates its mass away, all information about the material which entered to the blackhole seems to be lost. If one believes in standard quantum theory and unitary evolution preserving the information, and also forgets the standard quantum theory's prediction that state function reductions destroy information, one has a problem. Does the information really disappear? Or is the GRT description incapable to cope with the situation? Could information find a new representation?

Superstring models and AdS/CFT correspondence have inspired the proposal that a hologram results at the horizon and this hologram somehow catches the information by defining the hair of the blackhole. Since the radius of horizon is proportional to the mass of blackhole, one can however wonder what happens to this information as the radius shrinks to zero when all mass is Hawking radiated out.

What Hawking suggests is that a new kind of symmetry known as super-translations - a notion originally introduced by Bondi and Metzner - could somehow save the situation. Andrew Strominger has recently discussed the notion [B9] (`http://tinyurl.com/ycdv9e7y`). The information would be "stored to super-translations". Unfortunately this statement says nothing to me nor did not say to Bee and New Scientist reporter. The idea however seems to be that the information carried by Hawking radiation emanating from the blackhole interior would be caught by the hologram defined by the blackhole horizon.

Super-translation symmetry acts at the surface of a sphere with infinite radius in asymptotically flat space-times looking like empty Minkowski space in very distant regions. The action would be translations along sphere plus Poincare transformations.

What comes in mind in TGD framework is conformal transformations of the boundary of 4-D lightcone, which act as scalings of the radius of sphere and conformal transformations of the sphere. Translations however translate the tip of the light-cone and Lorentz transformations transform the sphere to an ellipsoid so that one should restrict to rotation subgroup of Lorentz group. Besides this TGD allows huge group of symplectic transformations of $\delta CD \times CP_2$ acting as isometries of WCW and having structure of conformal algebra with generators labelled by conformal weights.

8.2 What Are The Problems?

My fate is to be an aggressive dissident listened by no-one, and I find it natural to continue in the role of angry old man. Be cautious, I am arrogant, I can bite, and my bite is poisonous!

A. With all due respect to Big Guys, to me the problem looks like a pseudo problem caused basically by the breakdown of classical GRT. Irrespective of whether Hawking radiation is generated, the information about matter (apart from mass, and some charges) is lost if the matter indeed collapses to single infinitely dense point. This is of course very unrealistic and the question should be: how should we proceed from GRT.

   Blackhole is simply too strong an idealization and it is no wonder that Hawking's calculation using blackhole metric as a background gives rise to blackbody radiation. One might hope that Hawking radiation is genuine physical phenomenon, and might somehow carry the information by being not genuinely thermal radiation. Here a theory of quantum gravitation might help. But we do not have it!

B. What do we know about blackholes? We know that there are objects, which can be well described by the exterior Schwartschild metric. Galactic

centers are regarded as candidates for giant blackholes. Binary systems for which another member is invisible are candidates for stellar blackholes. One can however ask wether these candidates actually consist of dark matter rather than being blackholes. Unfortunately, we do not understand what dark matter is!

C. Hawking radiation is extremely weak and there is no experimental evidence pro or con. Its existence assumes the existence of blackhole, which presumably represents the failure of classical GRT. Therefore we might be seeing a lot of trouble and inspired heated debates about something, which does not exist at all! This includes both blackholes, Hawking radiation and various problems such as firewall paradox.

There are also profound theoretical problems.

A. Contrary to the intensive media hype during last three decades, we still do not have a generally accepted theory of quantum gravity. Super string models and M-theory failed to predict anything at fundamental level, and just postulate effective quantum field theory limit, which assumes the analog of GRT at the level of 10-D or 11-D target space to define the spontaneous compactification as a solution of this GRT type theory. Not much is gained.

   AdS/CFT correspondence is an attempt to do something in absence of this kind of theory but involves 10- or 11- D blackholes and does not help much. Reality looks much simpler to an innocent non-academic outsider like me. Effective field theorizing allows intellectual laziness and many problems of recent day physics will be probably seen in future as being caused by this lazy approach avoiding attempts to build explicit bridges between physics at different scales. Something very similar has occurred in hadron physics and nuclear physics and one has kind of stable of Aigeias to clean up before one can proceed.

B. A mathematically well-defined notion of information is lacking. We can talk about thermodynamical entropy - single particle observable - and also about entanglement entropy - basically a 2-particle observable. We do not have genuine notion of information and second law predicts that the best that one can achieve is no information at all!

   Could it be that our view about information as single particle characteristic is wrong? Could information be associated with entanglement and be 2-particle characteristic? Could information reside in the relationship of object with the external world, in the communication line? Not inside blackhole, not at horizon but in the entanglement of blackhole with the external world?

C. We do not have a theory of quantum measurement. The deterministic unitary time evolution of Schrödinger equation and non-deterministic state function reduction are in blatant conflict. Copenhagen interpretation escapes the problem by saying that no objective reality/realities exist. Easy trick once again! A closely related Pandora's box is that experienced time and geometric time are very different but we pretend that this is not the case.

   The only way out is to bring observer part of quantum physics: this requires nothing less than quantum theory of consciousness. But the gurus of theoretical physics have shown no interest to consciousness. It is much easier and much more impressive to apply mechanical algorithms to produce complex formulas. If one takes consciousness seriously, one ends up with the question about the variational principle of consciousness. Yes, your guess was correct! Negentropy Maximization Principle! Conscious experience tends to maximize conscious information gain. But how information is represented?

8.3 TGD View About Black Holes And Hawking Radiation

My own basic strategy is to not assume anything not necessitated by experiment or not implied by general theoretical assumptions - these of course represent the subjective element.

8.3.1 The basic ideas of TGD relevant for blackhole concept

The basic assumptions/predictions of TGD relevant for the recent discussion are following.

A. Space-times are 4-surfaces in $H = M^4 \times CP_2$ and ordinary space-time is replaced with many-sheeted space-time. This solves what I call energy problem of GRT by lifting gravitationally broken Poincare invariance to an exact symmetry at the level of embedding space H.
GRT type description is an approximation obtained by lumping together the space-time sheets to single region of M^4, with various fields as sums of induced fields at space-time surface geometrized in terms of geometry of H.
Space-time surface has both Minkowskian and Euclidian regions. Euclidian regions are identified in terms of what I call generalized Feynman/twistor diagrams. The 3-D boundaries between Euclidian and Minkowskina regions have degenerate induced 4-metric and I call them light-like orbits of partonic 2-surfaces or light-like wormhole throats analogous to blackhole horizons and actually replacing them. The interiors of blackholes are replaced with the Euclidian regions and every physical system is characterized by this kind of region.
Euclidian regions are identified as slightly deformed pieces of CP_2 connecting two Minkowskian space-time regions. Partonic 2-surfaces defining their boundaries are connected to each other by magnetic flux tubes carrying monopole flux.
Wormhole contacts connect two Minkowskian space-time sheets already at elementary particle level, and appear in pairs by the conservation of the monopole flux. Flux tube can be visualized as a highly flattened square traversing along and between the space-time sheets involved. Flux tubes are accompanied by fermionic strings carrying fermion number. Fermionic strings give rise to string world sheets carrying vanishing induced em charged weak fields (otherwise em charge would not be well-defined for spinor modes). String theory in space-time surface becomes part of TGD. Fermions at the ends of strings can get entangled and entanglement can carry information.

B. Strong form of General Coordinate Invariance (GCI) states that light-like orbits of partonic 2-surfaces on one hand and space-like 3-surfaces at the ends of causal diamonds on the other hand provide equivalent descriptions of physics. The outcome is that partonic 2-surfaces and string world sheets at the ends of CD can be regarded as basic dynamical objects.
Strong form of holography states the correspondence between quantum description based on these 2-surfaces and 4-D classical space-time description, and generalizes AdS/CFT correspondence. Conformal invariance is extended to the huge super-symplectic symmetry algebra acting as isometries of WCW and having conformal structure. This explains why 10-D space-time can be replaced with ordinary space-time and 4-D Minkowski space can be replaced with partonic 2-surfaces and string world sheets. This holography looks very much like the one we are accustomed with!

C. Quantum criticality of TGD Universe fixing the value(s) of the only coupling strength of TGD (Kähler coupling strength) as analog of critical temperature. Quantum criticality is realized in terms of infinite hierar-

chy of sub-algebras of super-symplectic algebraas isometries of WCW, the "world of classical worlds" consisting of 3-surfaces or by holography preferred extremals associated with them.

Given sub-algebra is isomorphic to the entire algebra and its conformal weights are $n \geq 1$-multiples of those for the entire algebra. This algebra acts as conformal gauge transformations whereas the generators with conformal weights $m < n$ act as dynamical symmetries defining an infinite hierarchy of simply laced Lie groups with rank $n-1$ acting as dynamical symmetry groups defined by Mac-Kay correspondence so that the number of degrees of freedom becomes finite. This relates very closely to the inclusions of hyper-finite factors - WCW spinors provide a canonical representation for them.

This hierarchy corresponds to a hierarchy of effective Planck constants $h_{eff} = n \times h$ defining an infinite number of phases identified as dark matter. For these phases Compton length and time are scale up by n so that they give rise to macroscopic quantum phases. Super-conductivity is one example of this kind of phase - charge carriers could be dark variants of ordinary electrons. Dark matter appears at quantum criticality and this serves as an experimental manner to produce dark matter. In living matter dark matter identified in this manner would play a central role. Magnetic bodies carrying dark matter at their flux tubes would control ordinary matter and carry information.

D. I started the work with the hierarchy of Planck constants from the proposal of Nottale stating that it makes sense to talk about gravitational Planck constant $\hbar_{gr} = GMm/v_0$, $v_0/c \leq 1$ (the interpretation of symbols should be obvious). Nottale found that the orbits of inner and outer planets could be modelled reasonably well by applying Bohr quantization to planetary orbits with tge value of velocity parameter differing by a factor 1/5. In TGD framework h_{gr} would be associated with magnetic flux tubes mediating gravitational interaction between Sun with mass M and planet or any object, say elementary particle, with mass m. The matter at the flux tubes would be dark as also gravitons involved. The Compton length of particle would be given by GM/v_0 and would not depend on the mass of particle at all.

   The identification $h_{gr} = h_{eff}$ is an additional hypothesis motivated by quantum biology, in particular the identification of biophotons as decay products of dark photons satisfying this condition. As a matter fact, one can talk also about h_{em} assignable to electromagnetic interactions: its values are much lower. The hypothesis is that when the perturbative expansion for two particle system does not converge anymore, a phase transition increasing the value of the Planck constant occurs and guarantees that coupling strength proportional to $1/h_{eff}$ decreases. This is one possible interpretation for quantum criticality. TGD provides a detailed geometric interpretation for the space-time correlates of quantum criticality.

   Macroscopic gravitational bound states not possible in TGD without the assumption that effective string tension associated with fermionic strings and dictated by strong form of holography is proportional to $1/h_{eff}^2$. The bound states would have size scale of order Planck length since for longer systems string energy would be huge. $h_{eff} = h_{gr}$ makes astroscopic quantum coherence unavoidable. Ordinary matter is condensed around dark matter. The counterparts of black holes would be systems consisting of only dark matter.

E. Zero energy ontology (ZEO) is central element of TGD. There are many motivations for it. For instance, Poincare invariance in standard sense cannot make sense since in standard cosmology energy is not conserved. The interpretation is that various conserved quantum numbers are length

scale dependent notions.

Physical states are zero energy states with positive and negative energy parts assigned to ends of space-time surfaces at the light-like boundaries of causal diamonds (CDs). CD is defined as Cartesian products of CP_2 with the intersection of future and past directed lightcones of M^4. CDs form a fractal length scale hierarchy. CD defines the region about which single conscious entity can have conscious information, kind of 4-D perceptive field. There is a hierarchy of WCWs associated with CDs. Consciously experienced physics is always in the scale of given CD.

Zero energy states identified as formally purely classical WCW spinor fields replace positive energy states and are analogous to pairs of initial and final, states and the crossing symmetry of quantum field theories gives the mathematical motivation for their introduction.

F. Quantum measurement theory can be seen as a theory of consciousness in ZEO. Conscious observer or self as a conscious entity becomes part of physics. ZEO gives up the assumption about unique universe of classical physics and restricts it to the perceptive field defined by CD.

In each quantum jump a re-creation of Universe occurs. Subjective experience time corresponds to state function reductions at fixed, passive bounary of CD leaving it invariant as well as state at it. The state at the opposite, active boundary changes and also its position changes so that CD increases state function by state function reduction doing nothing to the passive boundary. This gives rise to the experienced flow of geometric time since the distance between the tips of CD increases and the size of space-time surfaces in the quantum superposition increases. This sequence of state function reductions is counterpart for the unitary time evolution in ordinary quantum theory.

Self "dies" as the first state function reduction to the opposite boundary of CD meaning re-incarnation of self at it and a reversal of the arrow of geometric time occurs: CD size increases now in opposite time direction as the opposite boundary of CD recedes to the geometric past reduction by reduction.

Negentropy Maximization Principle (NMP) defines the variational principle of state function reduction. Density matrix of the subsystem is the universal observable and the state function reduction leads to its eigenspaces. Eigenspaces, not only eigenstates as usually.

Number theoretic entropy makes sense for the algebraic extensions of rationals and can be negative unlike ordinary entanglement entropy. NMP can therefore lead to a generation of NE if the entanglement correspond to a matrix proportional to a unitary matrix so that the density matrix of the final state is higher-D unit matrix. Another possibility is that entanglement matrix is algebraic but that its diagonalization in the algebraic extension of rationals used is not possible. This is expected to reduce the rate for the reduction since a phase transition increasing the size of extension is needed.

The weak form of NMP does not demand that the negentropy gain is maximum: this allow the conscious entity responsible for reduction to decide whether to increase maximally NE resources of the Universe or not. It can also allow larger NE increase than otherwise. This freedom brings the quantum correlates of ethics, moral, and good and evil. p-Adic length scale hypothesis and the existence of preferred p-adic primes follow from weak form of NMP and one ends up naturally to adelic physics.

8.3.2 Could electric-magnetic duality allow to understand $1/h_{eff}^2$ dependence of the effective string tension?

Electric-magnetic duality (possibly the TGD counterpart of AdS/CFT duality) might allow to understand the proportionality of effective string tension to $1/h_{eff}^2$.

A. The *effective* string tension assignable to fermionic strings accompanying magnetic flux tubes and allowing to express Minkowskian Kähler as stringy action must be inversely proportional to $1/h_{eff}^2$ in order to obtain gravitationally bound states in macroscopic length scales identified as structure for which partonic 2-surfaces are connected by strings accompanying flux tubes. This requirement is not easy to prove since $1/\alpha_K$ is proportional to h_{eff}. Could electric-magnetic duality imply this formula with the interpretation that the effective string tension corresponds to Kähler action for string like object?

B. The Dirac condition would give

$$\frac{g_m g_K}{2\pi} = z \in Z$$

giving

$$\frac{1}{\alpha_m} = \frac{4\alpha_K}{z^2} = \frac{\pi}{2qz^2} \quad .$$

if one accepts the argument of [K52] requiring that Kähler action for CP_2 type vacuum extremal is rational number $q = m/n$ guaranteeing that the exponent of Kähler action for Euclidian space-time regions of preferred extremals belongs to an a finite-dimensional extension of p-adic numbers generated by a root of e (note that e is adelically completely unique). This argument implies $\alpha_K = \pi/8q$ (note that this result is in conflict with earlier ideas about the algebraic structure of α_K [K47] based on much more ad hoc argumens).
This would give

$$\frac{1}{2g_m^2} = \frac{1}{16qz^2} \quad .$$

The contribution of the action from Minkowskian regions would be proportional to π and in case of string like objects string area A should be a rational number. The value of string tension would be reduced by a factor

$$\frac{g_K^2}{g_m^2} = \frac{4\alpha_K^2}{z^2} \quad .$$

This is inconsistent with the model of cosmic strings [K16] predicting much larger tension (consistency would require $g_m = g_K$), and would lead to problems in the model of galactic dark matter assuming that galactic strings are like pearls in necklace around single cosmic string. The duality can thus hold only for M^4 type regions of space-time surface.

C. The formula $g_K^2/g_m^2 = 4\alpha_K^2/z^2$ implies $1/h_{eff}^2$ proportionality for the effective string tension if the formula $h_{eff} = z \times h$ makes sense. z would correspond to the number of sheets for the magnetic flux tubes defining covering of M^4.

8.3.3 The analogs of blackholes in TGD

Could blackholes have any analog in TGD? What about Hawking radiation? The following speculations are inspired by the above general vision.

A. Ordinary blackhole solutions are not appropriate in TGD. Interior space-time sheet of *any* physical object is replaced with an Euclidian space-time region. Also that of blackhole by perturbation argument based on the observation that if one requires that the radial component of blackhole metric is finite, the horizon becomes light-like 3-surface analogous to the light-like orbit of partonic 2-surface and the metric in the interior becomes Euclidian.

B. The analog of blackhole can be seen as a limiting case for ordinary astrophysical object, which already has blackhole like properties due to the presence of $h_{eff} = n \times h$ dark matter particles, which cannot appear in the same vertices with visible manner. Ideal analog of blackhole consist of dark matter only, and is assumed to satisfy the $h_{gr} = h_{eff}$ already discussed. It corresponds to region with a radius equal to Compton length for arbitrary particle $R = GM/v_0 = r_S/2v_0$, where r_S is Schwartschild radius. Macroscopic quantum phase is in question since the Compton radius of particle does not depend on its mass. Blackhole limit would correspond to $v_0/c \to 1$ and dark matter dominance. This would give $R = r_S/2$. naïve expectation would be $R = r_S$ (maybe factor of two is missing somewhere: blame me!).

C. NMP implies that information cannot be lost in the formation of blackhole like state but tends to increase. Matter becomes totally dark and the NE with the partonic surfaces of external world is preserved or increases. The ingoing matter does not fall to a mass point but resides at the partonic 2-surface which can have arbitrarily large surface. It can have also wormholes connecting different regions of a spherical surface and in this manner increase its genus. NMP, negentropy , negentropic entanglement between $h_{eff} = n \times h$ dark matter systems would become the basic notions instead of second law and entropy.

D. There is now a popular article (`http://tinyurl.com/o6n3k4y` explaining the intuitive picture behind Hawking's proposal. The blackhole horizon would involve tangential flow of light and particles of the infalling matter would induce supertranslations on the pattern of this light thus coding information about their properties to this light. After that this light would be radiated away as analog of Hawking radiation and carry out this information.

   The objection would be that in GRT horizon is no way special - it is just a coordinate singularity. Curvature tensor does not diverge either and Einstein tensor and Ricci scalar vanish. This argument has been used in the firewall debates to claim that nothing special should occur as horizon is traversed. So: why light would rotate around it? No reason for this!

   The answer in TGD would be obvious: horizon is replaced for TGD analog of blackhole with a light-like 3-surface at which the induced metric becomes Euclidian. Horizon becomes analogous to light front carrying not only photons but all kinds of elementary particles. Particles do not fall inside this surface but remain at it!

   The objection now is that photons of light front should propagate in direction normal to it, not parallel. The point is however that this light-like 3-surface is the surface at which induced 4-metric becomes degenerate: hence massless particles live on it.

E. The replacement of second law with NMP leads to ask whether a generalization of blackhole thermodynamics (`http://tinyurl.com/y7pvj23x`) does make sense. Since blackhole thermodynamics characterizes Hawking radiation, the generalization could make sense at least if there exist analog for the Hawking radiation (`http://tinyurl.com/md6mmvg`). Note that also geometric variant of second law makes sense.

   Could the analog of Hawking radiation be generated in the first state

function reduction to the opposite boundary, and be perhaps be assigned with the sudden increase of radius of the partonic 2-surface defining the horizon? Could this burst of energy release the energy compensating the generation of gravitational binding energy? This burst would however have totally different interpretation: even gamma ray bursts from quasars could be considered as candidates for it and temperature would be totally different from the extremely low general relativistic Hawking temperature of order

$$T_{GR} = \frac{\hbar}{8\pi GM} \quad ,$$

which corresponds to an energy assignable to wavelength equal to 4π times Schwartschild radius. For Sun with Schwartschild radius $r_S = 2GM = 3$ km one has $T_{GR} = 3.2 \times 10^{-11}$ eV.

One can of course have fun with formulas to see whether the generalizaton assuming the replacement $h \to h_{gr}$ could make sense physically. Also the replacement $r_S \to R$, where R is the real radius of the star will be made.

A. Blackhole temperature can be formally identified as surface gravity

$$T = \frac{\hbar_{gr}}{\hbar}\frac{\hbar GM}{2\pi R^2} = \frac{m}{8\pi v_0}\frac{r_S^2}{R^2} \quad .$$

For Sun with radius $R = 6.96 \times 10^5$ km one has $T/m = 3.2 \times 10^{-11}$ giving about 3×10^{-2} eV for proton. This is by 9 orders higher than ordinary Hawking temperature. Amazingly, this temperature equals to room temperature! Is this a mere accident? If one takes seriously TGD inspired quantum biology in which quantum gravity plays a key role [K37], this does not seem to be the case. Note that for electron the temperature would correspond to energy $3/2 \times 10^{-5}$ eV which corresponds to 4.5 GHz frequency for ordinary Planck constant.

It must be however made clear that the value of v_0 for dark matter could differ from that deduced assuming that entire gravitational mass is dark. For $M \to M_D = kM$ and $v_0 \to \sqrt{k}v_0$ the orbital radii remain unchanged but the velocity of dark matter object at the orbit scales to $\sqrt{k}v_0$. This kind of scaling is suggested by the fact that the value of h_{gr} seems to be too large as compared to that deduced by the identification of biophotons as decay results of dark photons with $h_{eff} = h_{gr}$ (some arguments suggest the value $k \simeq 2 \times 10^{-4}$) [**?**].

Note that for the radius $R = r_S/2\sqrt{v_0\pi}$ the thermal energy exceeds the rest mass of the particle. For neutron stars this limit might be achieved.

B. Blackhole entropy

$$S_{GR} = \frac{A}{4\hbar G} = 4\pi\frac{GM^2}{\hbar} = 4\pi\frac{M^2}{M_{Pl}^2}$$

would be replaced with the negentropy for dark matter making sense also for systems containing both dark and ordinary matter. The negentropy $N(m)$ associated with a flux tube of given type would be a fraction h/h_{gr} from the total area of the horizon using Planck area as a unit:

$$N(m) = \frac{h}{h_{gr}} \times \frac{A}{4\hbar G} = \frac{h}{h_{gr}} \times \frac{R^2}{r_S^2} S_{GR} = v_0 \frac{M}{m}\frac{R^2}{r_S^2} \quad .$$

The dependence on m makes sense since a given flux tube type characterized by mass m determining the corresponding value of h_{gr} has its own negentropy and the total negentropy is the sum over the particle species. The negentropy of Sun is numerically much smaller that corresponding blackhole entropy.

C. Horizon area is proportional to $(GM/v_0)^2 \propto h_{eff}^2$ and should increase in discrete jumps by scalings of integer and be proportional to n^2.

How does the analog of blackhole evolve in time? The evolution consists of sequences of repeated state function reductions at the passive boundary of CD followed by the first reduction to the opposite boundary of CD followed by a similar sequence. These sequences are analogs of unitary time evolutions. This defines the analog of blackhole state as a repeatedly re-incarnating conscious entity and having CD, whose size increases gradually. During given sequence of state function reductions the passive boundary has constant size. About active boundary one cannot say this since it corresponds to a superposition of quantum states.

The reduction sequences consist of life cycles at fixed boundary and the size of blackhole like state as of any state is expected to increase in discrete steps if it participates to cosmic expansion in average sense. This requires that the mass of blackhole like object gradually increases. The interpretation is that ordinary matter gradually transforms to dark matter and increases dark mass $M = R/G$.

Cosmic expansion is not observed for the sizes of individual astrophysical objects, which only co-move. The solution of the paradox is that they suddenly increase their size in state function reductions. This hypothesis allows to realize Expanding Earth hypothesis in TGD framework [K20]. Number theoretically preferred scalings of blackhole radius come as powers of 2 and this would be the scaling associated with Expanding Earth hypothesis.

8.4 More About BMS Supertranslations

Bee (see `http://tinyurl.com/z4p9h7l`) had a blog posting about the new proposal of Hawking, Perry and Strominger (HPS, see `http://tinyurl.com/z6tpzar`) [B9] to solve the blackhole information loss problem. In the article Maxwellian electrodynamics is taken as a simpler toy example.

A. One can assign to gauge transformations conserved charges. Gauge invariance tells that these charges vanish for all gauge transformations, which approach trivial transformation at infinity. Now however it is assumed that this need not happen. The assumption that action is invariant under these gauge transformations requires that the radial derivative of the function Φ defining gauge transformation approaches zero at infinity but gauge transformation can be non-trivial in the angle coordinates of sphere S^2 at infinity. The allowance of these gauge transformations implies infinite number of conserved charges and QED is modified. The conserved gauge charges are generalizations of ordinary electric charged defined as electric fluxes (defining zero energy photons too) and reduce to electric gauge fluxes with electric field multiplied by Φ.

B. For Maxwell's theory the ordinary electric charged defined as gauge flux must vanish. The coupling to say spinor fields changes the situation and due to the coupling the charge as flux is expressible in terms of fermionic oscillator operators and those of U(1) gauge field . For non-constant gauge transformations the charges are at least formally non-trivial even in absence of the coupling to fermions and linear in quantized U(1) gauge field.

C. Since these charges are constants of motion and linear in bosonic oscillator operators, they create or annihilate gauge bosons states with vanishing energy: hence the term soft hair. Holographists would certainly be happy since the charges could be interpreted as representing pure information. If one considers only the part of charge involving annhilation operators one can consider the possibility that in quantum theory physical states are eigenstates of these "half charges" and thus coherent states which are the quantum analogs of classical states. Infinite vacuum degeneracy would be

obtained since one would have infinite number of coherent states labelled by the values of the annihilation operator parts of the charges. A situation analogous to conformal invariance in string models is obtained if all these operators either annihilate the vacuum state or create zero energy state.

D. If these U(1) gauge charges create new ground states they could carry information about matter falling into blackhole. Particle physicist might protest this assumption but one cannot exclude it. It would mean generalization of gauge invariance to allow gauge symmetries of the proposed kind. What distinguishes U(1) gauge symmetry from non-Abelian one is that fluxes are well-defined in this case.

E. In the gravitational case the conformal transformations of the sphere at infinity replace U(1) gauge transformations. Usually conformal invariance would requite that almost all conformal charges vanish but now one would not assume this. Now physical states would be eigentates of annihilation operator parts of Virasoro generators L_n and analogous to coherent states and code for information about the ground state. In 4-D context interpretation as strong form of holography would make sense.The critical question is why should one give up conformal invariance as gauge symmetry in the case of blackholes.

It is is interesting to look TGD analogy for BMS supertranslation symmetries. Not for solving problems related to blackholes - TGD is not plagued by these problems - but because the analogs of these symmetries are very important in TGD framework.

A. In TGD framework conformal transformations of boundary of causal diamond (CD) correspond to the analogs of BMS transformations. Actually conformal transformations of not only sphere (with constant value of radial coordinate labeling points of light rays emerging from the tip of the light-cone boundary) but also in radial degrees of freedom so that conformal symmetries generalize. This happens only in case of 4-D Minkowski space and also for the light-like 3-surfaces defining the orbits of partonic 2-surfaces. One actually obtains a huge generalization of conformal symmetries. As a matter of fact, Bee wondered whether the information related to radial degrees of freedom is lost: one might argue that holography eliminates them.

B. Amusingly, one obtains also the analogs of U(1) gauge transformations in TGD! In TGD framework symplectic transformations of light-cone boundary times CP_2 act like U(1) gauge transformations but are not gauge symmetries for Kähler action except for vacuum extremals! This is assumed in the argument of the article to give blackhole its soft hair but without any reasonable justification. One can assign with these symmetries infinite number of non-trivial conserved charges: super-symplectic algebra plays a fundamental role in the construction of the geometry of "World of Classical Worlds" (WCW).

   At embedding space level the counterpart for the sphere at infinity in TGD with the sphere at which the lightcone-boundaries defining the boundary of causal diamond (CD) intersect. At the level of space-time surfaces the light-like orbits of partonic 2-surfaces at which the signature of the induced metric changes are the natural counterparts of the 3-surface at infinity.

   In TGD framework Noether charges vanish for some subalgebra of the entire algebra isomorphic to it and one obtains a hierarchy of quantum states (infinite number of hierarchies actually) labelled by an integer identifiable in terms of Planck constant $h_{eff}/h = n$. If colleagues managed to realize that BMS has a huge generalization in the situation when space-times are surface in $H = M^4 \times CP_2$, floodgates would be open.

   One obtains a hierarchy of breakings of superconformal invariance, which for some reason has remained un-discovered by string theorists. The natu-

ral next discovery would be that one indeed obtains this kind of hierarchy by demanding that conformal gauge charges still vanish for a sub-algebra isomorphic with the original one. Interesting to see who will make the discovery. String theorists have failed to realize also the completely unique aspects of generalized conformal invariance at 3-D light-cone boundary raising dimension $D = 4$ to a completely unique role. To say nothing about the fact that M^4 and CP_2 are twistorially completely unique. I would continue the list but it seems that the emergence super string elite has made independent thinking impossible, or at least the communications of the outcomes of independent thinking.

Does one obtain the analogs of generalized gauge fluxes for Kähler action in TGD framework?

A. The first thing to notice is that Kähler gauge potentials are not the primary dynamical variables. This role is taken by the embedding space coordinates. The symplectic transformations of CP_2 act like gauge transformations mathematically but affect the induced metric so that Kähler action does not remain invariant. The breaking is small due to the weakness of the classical gravitation. Indeed, if symplectic transformations are to define isometries of WCW, they cannot leave Kähler action invariant since the Kähler metric would be trivial! One can deduce symplectic charges as Noether charges and they might serve as analogs fo the somewhat questionable generalized gauge charges in HPS proposal.

B. If the counterparts of the gauge fluxes make sense they must be associated with partonic 2-surfaces serving as basic building bricks of elementary particles. Field equations do not follow from independent variations of Kähler gauge potential but from that of embedding space coordinates. Hence identically conserved Kähler current does not vanish for all extremals. Indeed, so called massless extremals (MEs) [K8] can carry a non-vanishing light-like Kähler current, whose direction in the general case varies. MEs are analogous to laser beams and if the current is Kähler charged it means that one has massless charged particle.

C. Since Kähler action is invariant also under ordinary gauge transformations one can formally derive the analog of conserved gauge charge for non-constant gauge transformation Φ. The question is whether this current has any physical meaning.
One obtains current as contraction of Kähler form and gradient of Φ:

$$j_\Phi^\alpha = J^{\alpha\beta}\partial_\beta\Phi \ , \tag{8.1}$$

which is conserved only if Kähler current vanishes so that Maxwell's equations are true or if the contraction of Kähler current with gradient of Φ vanishes:

$$j_\Phi^\alpha\partial_\alpha\Phi = 0 \ . \tag{8.2}$$

The construction of preferred extremals leads to the proposal that the flow lines of Kähler current are integrable in the sense that one can assign a global coordinate Ψ with them. This means that Kähler current is proportional to gradient of scalar function Ψ:

$$j_\Phi^\alpha = g^{\alpha\beta}\partial_\beta\Psi \ . \tag{8.3}$$

This implies that the gradients of Φ and Ψ are orthogonal. If Kähler current is light-like as it is for the known extremals, Φ is superposition

of light-like gradient of Ψ and of two gradients in a sub-space of tangent space analogous to space of two physical polarizations. Essentially the local variant of the polarization-wave vector geometry of the modes of radiative solutions of Maxwell's equations is obtained. What is however important that superposition is possible only for modes with the same local direction of wave vector ($\nabla\Psi$) and local polarization.
Kähler current would be scalar function k times gradient of Ψ :

$$j_\Phi^\alpha = kg^{\alpha\beta}\partial_\beta\Psi \quad . \tag{8.4}$$

The proposal for preferred extremals generalizing at least MEs leads to the proposal that the extremals define two light-like coordinates and two transversal coordinates.

D. The conserved current decomposes to a sum of interior and boundary terms. Consider first the boundary term. The boundary contributions to the generalized gauge charge is given by the generalized fluxes

$$Q_{\delta,\Phi} = \oint J^{tn}\Phi g^{1/2} \tag{8.5}$$

over partonic 2-surfaces at which the signature of the induced metric changes from Euclidian to Minkowskian. These contributions come from both sides of partonic 2-surface corresponding to Euclidian and Minkowskian metric and they differ by a imaginary unit coming from $g^{1/2}$ at the Minkoskian side. $Q_{\delta,\Phi}$ could vanish since $g^{1/2}$ approaches zero because the signature of the induced metric changes at the orbit of the partonic 2-surfaces. What happens depends on how singular the electric component of gauge potential is allow to be. Weak form of electric magnetic duality proposed as boundary condition implies that the electric flux reduces to magnetic flux in which case the result would be magnetic flux weighted by Φ.

E. Besides this there is interior contribution, which is Kähler current multiplied by -Φ:

$$Q_{int,\Phi} = \int j^t\Phi g^{1/2} \quad . \tag{8.6}$$

This contribution is present for MEs.

F. Could one interpret these charges as genuine Noether charges? Maybe! The charges seem to have physical meaning and they depend on extremals. The functions Φ could even have some natural physical interpretation. The modes of the induced spinor fields are localized at string world sheets by strong form of holography and by the condition that electric charge is well defined notion for them. The modes correspond to complex scalar functions analogous to powers z^n associated with the modes of conformal fields. Maybe the scalar functions could be assigned to the second quantized fermions. Note that one cannot interpret these contributions in terms of oscillator operators since the second quantization of the induced gauge fields does not make sense. This would conform with strong form of holography which in TGD framework sense that the descriptions in terms of fundamental fermions and in terms of classical dynamics of Kähler action are dual. This duality suggest that the quantal variants of generalized Kähler charges are expressible in terms of fermionic oscillator operators generating also bosonic states as analogs of bound states. The generalized charge eigenstates might be also seen as analogs of coherent states.

9 How to demonstrate quantum superposition of classical gravitational fields?

There was rather interesting article in Nature [B4] (see `http://tinyurl.com/ybylck8m`)) by Marletto and Vedral about the possibility of demonstrating the quantum nature of gravitational fields by using weak measurement of classical gravitational field affecting it only very weakly. There is also an article in arXiv by the same authors [B3] (see `http://tinyurl.com/ybylck8m`). The approach relies on quantum information theory.

The gravitational field would serve as a measurement interaction and the weak measurements would be applied to gravitational witness serving as probe - the technical term is ancilla. Authors claim that weak measurements giving rise to analog of Zeno effect could be used to test whether the quantum superposition of classical gravitational fields (QSGR) does take place. One can however argue that the extreme weakness of gravitation implies that other interactions and thermal perturbations mask it completely in standard physics framework. Also the decoherence of gravitational quantum states could be argued to make the test impossible.

One must however take these objections with a big grain of salt. After all, we do not have a theory of quantum gravity and all assumptions made about quantum gravity might not be correct. For instance, the vision about reduction to Planck length scale might be wrong. There is also the mystery of dark matter, which might force considerable motivation of the views about dark matter. Furthermore, General Relativity itself has conceptual problems: in particular, the classical conservation laws playing crucial role in quantum field theories are lost. Superstrings were a promising candidate for a quantum theory of gravitation but failed as a physical theory.

In TGD, which was born as an attempt to solve the energy problem of TGD and soon extended to a theory unifying gravitation and standard model interactions and also generalizing string models, the situation might however change. In zero energy ontology (ZEO) the sequence of weak measurements is more or less equivalent to the existence of self identified as generalized Zeno effect! The value of $h_{eff}/h = n$ characterizes the flux tubes mediating various interactions and can be very large for gravitational flux tubes (proportional to GMm/v_0, where $v_0 < c$ has dimensions of velocity, and M and m are masses at the ends of the flux tube) with $Mm > v_0 m_{Pl}^2$ (m_{Pl} denotes Planck mass) at their ends. This means long coherence time characterized in terms of the scale of causal diamond (CD). The lifetime T of self is proportional to h_{eff} so that for gravitational self T is very long as compared to that for electromagnetic self. Selves could correspond sub-selves of self identifiable as sensory mental images so that sensory perception would correspond to weak measurements and for gravitation the times would be long: we indeed feel the gravitational force all the time. Consciousness and life would provide a basic proof for the QSGR (note that large neutron has mass of order Planck mass!).

9.1 Is gravitation classical or quantal?

The conflict between general relativity (GRT) in which gravitation has classical description in terms of geometry and quantum theory was noticed very early, certainly already by Einstein, which explains his refusal to accept quantum theory. Feynman crystallized the problem [B4] and was led to suggest that gravitation must be described quantally. The following arguments suggests that classical gravitational fields reducing to space-time geometries in GRT are necessary to describe gravitationally bound states.

A. The electron in atom is de-localized so that one must have also quantum superposition superposition of classical gravitational fields associated with

it. This requires allowance of a space of classical gravitational fields, where one has Schrödinger amplitudes. In GRT framework this means allowance of the space of space-time geometries or at least the space of 3-geometries and Wheeler indeed proposed this notion (super-space).
The same is true in electrodynamics, where pure QED gives wrong predictions for hydrogen atom but the simple model based on classical em fields gives excellent predictions. This can be understood in TGD in terms of the notion of bound states involving fusion of 3-surfaces to single 3-surface connected by magnetic flux tubes serving also as correlates for quantum entanglement.
From TGD point of view the path integral quantization of quantum field theories was a mistake and prevented the discovery geometrization of field concept in terms of sub-manifold geometry and the notion of WCW generalizing the geometrization of physics program of Einstein to the entire quantum theory.

B. The quantization of gravitation as quantum field theory (QFT) in flat Minkowski space background is not enough. One must replace world with WCW as done in TGD, where worlds correspond to space-time surfaces in $M^4 \times CP_2$. The induction of process for metric and spinor connection geometrizes various fields and the classical worlds are space-time surfaces.

This leads to a completely new vision about gravitation and other interactions consistent with the standard model leading to notions like hierarchy of Planck constants allowing quantum coherence in even astrophysical length and time scales, p-adic physics, and eventually adelic physics as physics of sensory experience and cognition. What is remarkable that the TGD counterpart of ER-EPR correspondence discovered much before ER-EPR states that magnetic flux tubes serve as correlates for negentropic entanglement and are accompanied by fermionic strings.

A. Each interaction is characterized by its own magnetic flux tubes and by the value of Planck constant $h_{eff} = n \times h$ labelling phases of ordinary matter identified as dark matter. h_{eff} actually has number theoretic interpretation in adelic physics [L27, L29].

B. The Planck constant associated with the magnetic flux tube is proportional to the product of corresponding charges at its ends [K19, **?**, K45, K36]. For gravitational interaction one has $\hbar_{eff} = \hbar_{gr} = GMm/v_0$, where M and m are masses at the ends of the flux tube and $v_0 < c$ is parameter with dimensions of velocity. For electromagnetic interaction one has $\hbar_{em} = Ze^2Q_1Q_2/v_0$. The value of h_{gr} is much larger than h and h_{em} if one has $Mm/v_0 > m_{Pl}^2$ (m_{Pl} denotes Planck mass). For $Mm < v_0 m_{Pl}^2$ one has $h_{eff} = h_{gr} = h$.
The large values of h_{gr} suggests that gravitational quantum coherence is possible even in astrophysical scales: Nottale [**?**] indeed proposed that one can regard planetary orbits as Bohr orbits. The fountain effect of superfluidity could be one example of this [**?**]. h_{gr} would be also in key role in living matter.

This argument relies on mere logic and to my opinion makes the notion of WCW (or some analog of it) compelling if one accepts geometrization of gravitation.

9.2 Zeno effect and weak measurements

The proposal of Marletto and Vedral [B3, B3] is inspired by quantum information theory. Some of the basic notions involved ancilla or probe, gravitational witness, and weak measurement giving rise to an analog of Zero effect.

9.2.1 Can one test quantum character of gravitation experimentally?

One can also approach the situation purely experimentally by trying to find effects demonstrating the quantum character of gravitation. The basic problem is the extreme weakness of gravitation. It seems that quantum gravitational effects are masked by other interactions and thermodynamical effects.

A. The simplest question is whether particles in gravitational field of say Earth behave quantally in analogy with the behavior in electromagnetic fields. This is found to be case by studying neutrons in the Earth's gravitational field. This finding by the way killed the idea about entropic gravity identifying gravity as thermodynamical effect [K50]. This experiment does not however say anything about whether classical gravitational fields form quantum superpositions.

B. The emission rate of gravitons by elementary particles are extremely low. Hence on cannot test the theory at elementary particle level by measuring graviton emission and absorption or by studying the gravitational counterparts of bound states such as atoms - this if one assumes standard value of Planck constant only. Also the graviton interference effects and effects like Bose-Einstein condensation seem to be impossible to test. In the early Universe strong gravitational fields exist and inflationary period could show quantum gravitational effects. This kind of tests are however indirect. In TGD framework the cosmic string based model for galactic dark can be seen as support for quantum gravitation.

C. The situation changes if one allows the hierarchy of Planck constants. In this case one can have the analogs of atoms as planetary systems. One can argue that quantum character of gravitational bound states solves the analog of infrared catastrophe of hydrogen atom, which led to the birth of atomic physics. The formation of blackhole would correspond to infrared catastrophe. Dark gravitons with large h_{gr} have large energies $E = h_{gr}f$ and one can even speculate with the possibility of direct observation of low energy dark gravitons as they transform to bunches of $h_{gr}/h = n$ ordinary gravitons [K36].

The experiment testing QSGR should generate a de-localized particle - say superposition of two sharply localized states. This kind of de-localized states appear in atomic and molecular physics and superconductors and Bose-Einstein condensates provide macroscopic variants of these states. One should test whether these states involve QSGR. Standard physics says that for larger objects this kind of de-localized states are not possible.

If one allows hierarchy of Planck constants, in particular $h_{gr} = h_{eff}$ hypothesis, the situation changes. The fountain effect of super-fluidity could be a representative example [**?**]. The de-localization of particles at magnetic flux tubes in the phase transition generating dark matter would directly affect the gravitational field created by system and it might be possible detect this change. Quite generally, quantum critical systems would be excellent candidates for demonstrating quantum superposition of classical gravitational fields.

The challenge is how to demonstrate the existence of QSGR. Gravitational interaction is too weak but could hierarchy of Planck constants change the situation somehow?

9.2.2 The notion of weak measurement

Contrary to my prejudice, the notion of weak measurement (see `http://tinyurl.com/zt36hpb`) makes sense mathematically and is different from the notion of weak values (see `http://tinyurl.com/yc63pygw`), which to my opinion are mathematical nonsense. The idea of weak measurement is to entangle the weakly measured system with probe and measure the state of the probe

rather than system repeatedly. If the initial state of probe is strongly localized to some value of the observable measured, the sequence of measurements does not affect much the weakly measured system and one can monitor it.

A. One has tensor product $A \otimes B$ of two systems and weak interaction entangling them and realized by interaction Hamiltonian H, whose exponential gives rise to time evolution. Time evolution consists of periods Δt_n ending by a measurement of some observable x for B giving eigenvalue q. Each period induces a unitary evolution of A by a Hamiltonian, which does not commute with x. The weakness of the interaction and strong localization of the initial state of B imply that A is only weakly perturbed and ancilla B follows its state in good accuracy.

B. In the simplest situation both system A and B are characterized by single commuting observable x analogous to position operator and its conjugate p. A is the system to be monitored and B is the ancilla. The initial state $|\Psi(0)$ of A is arbitrary and the initial state $\Phi(0)$ of the probe B can be assumed to be Gaussian (for instance): harmonic oscillator could be in question.

C. The canonical choice for the interaction Hamiltonian would be $H = kx \otimes p$. Quantum measurement of x for the ancilla (probe) B after time Δt implies a localization to the state $|q\rangle$. After than unitary evolution induces again de-localization and until new position measurement occurs. One can solve the Schrödinger equation and express the outcome of the measurement of the position x for B as

$$\begin{aligned} \Psi(\Delta t)\Phi(\Delta t) &= M_q \Psi(0) \otimes |q\rangle \ , \\ M_q &= \frac{1}{N} \times exp(-ik\Delta t x \otimes p) \ , \\ N &= \sqrt{\langle \Psi(0)|M_q^\dagger M_q|\Psi(0)\rangle} \ . \end{aligned} \tag{9.1}$$

The unitary operator M_q - Kraus operator - depends on position operator x. It has the eigenvalue q as a parameter.
For Gaussian initial state $\Psi(0)$ one has

$$M_q = \frac{1}{(2\pi\sigma^2)^{1/4}} exp((-q-x)^2/4\sigma^2) \ . \tag{9.2}$$

If the measured state is localized around the eigenvalue of x_0 of x, this distribution is peaked around x_0 and also the eigenvalue of the ancilla position q remains near it. One might say that ancilla follows the state of the weakly measurement system. Note that H is only interaction Hamiltonian and contains also part associated with the weakly measured system.
It is important that the unitary evolution induced by $H = kx \otimes p$ does not leave the eigenstate of q invariant but induces shift by x. Therefore the repeated measurements of q imply a stepwise motion in q-space inducing a similar motion for Ψ in A.

Weak measurement brings strongly in mind Zeno effect in which repeated measurement leave the state unaffected. In the recent case this is not the case since H does not commute with position operator of ancilla. Remarkably, the weak measurement is highly analogous to the generalized Zeno effect in zero energy ontology (ZEO) defining self as sequence of "small state function reductions" at the active boundary of causal diamond (CD) and giving rise to the experience about flow of time.

A. Weak measurement could serve as a model for sensory perception following monitoring target. Self indeed consists of sequences of unitary time

evolutions in which system entangles with external world although the its state about the passive boundary of CD representing the unchanging part of self is unaffected. Magnetic flux tubes serve as correlates for both entanglement and attention.

B. The members of state pairs at passive boundary of CD remain unaffected. The sequence of small state function reductions ends up with the death of self as "big" state function reduction at opposite boundary of CD takes place. For sub-selves defining mental images this would mean that attention ceases. Self can be said to performing weak measurements as long it lives! As self dies a time reversed self assignable to the opposite boundary of CD is created.

Remark: There is also so called interaction free measurement (see `http://tinyurl.com/y7zq97q2`), which I considered for some years ago as counterpart of self. This hypothesis turned out to be un-necessary. Interaction free measurement does not seem to be quite same as weak measurement.

9.2.3 Weak measurement induced by measurement of classical gravitational fields

How could one apply weak measurement to monitor gravitational fields and their quantum superpositions?

A. One could consider replacing x and p by some components of classical gravitational field and their canonical conjugates at some point of space. If one could arrange the measurement interaction to be of the form described above, one could follow the state of classical gravitational field and also the quantum superposition for the values of classical gravitational field - say in given position. The expectation of the operator M_q for the state would reveal the distribution in coordinate x characterizing the value of gravitational field. This would however require successful quantization of gravitational fields. Second problem relates to the measurement interaction: how could one arrange it to be of the desired form.

B. Could the measurement interaction be taken to be the gravitational interaction between A and B? Now the positions for two masses m_A and m_B would become observables and measurement interaction would induce motion in A and the distribution of position for the mass m_A would be visible in the unitary operator M_q acting on state Ψ of the target.
The extreme weakness of gravitational interaction indeed makes it an obvious candidate for witness interaction. Most importantly, the classical gravitational field created by the target at the position of the ancilla appears in the measurement interaction. The weakness however suggests that gravitation as a measurement interaction is masked by other interactions and by thermal noise. The analog of Zeno period is expected to be very short in standard quantum theory.

If I understood correctly, the authors suggests that the occurrence of the analog of Zeno period is used as a way to demonstrate the superposition of classical gravitational fields. I could not quite follow the argument. Zeno period should be present also when there is no de-localization of masses m_A and m_B. Information about M_q is needed in order to deduce whether de-localization and superposition of classical gravitational fields is present. If gravitational field is purely classical, one cannot even talk about weak measurement.

9.2.4 What about the situation in TGD?

In TGD situation changes. ZEO and TGD inspired theory of consciousness enter into play. It would be enough to prove experimentally that the notion of self, which is analog of weak measurement period and an outcome of TGD

based view about quantum gravitation relying on the notion of WCW and ZEO, makes sense.

A. Not surprisingly, the hierarchy of Planck constants would play a key role. The lifetime T of self is proportional to $h_{eff}/h = n$, and for gravitational flux tubes one has $\hbar_{eff} = \hbar_{gr} = GMm/v_0$. h_{gr} is much much larger than $h_{eff} = h_{em}$ for the flux tubes mediating electromagnetic interactions (note that flux tubes gives rise to the analog of ER-EPR correspondence which I proposed much before ER-EPR).
For $Mm > v_0 m_{Pl}^2$ dark matter with $h_{gr} > h$ is possible. Interestingly, Planck mass corresponds in living matter to a water blob with size of large neuron. For $v_0 < c$ neurons could define a pair of systems allowing to test the superposition of classical gravitational fields. One could consider de-localization of neurons or systems associated with them. The de-localization of dark particles at magnetic flux tubes might help here since it would redistribute part of the matter affecting the gravitational field created by it. The detection of gravitational field of neuron might allow to detect this phase transition: neuron would apparently lose part of its weight.

B. The phase transition generating dark matter in say neuronal system might allow detection via the emergence of generalized Zeno effect. Generalized Zeno effect - identifiable as life-time of self - would serve as a signature of gravitational entanglement. Gravitational Zeno effect - maybe identifiable in terms of sensory perception of gravitational field of target - lasts much longer than its electromagnetic counterpart and its existence would demonstrate that QSGR is real! This would also demonstrate that TGD inspired theories of consciousness and quantum biology, where h_{gr} plays a key role, might have something to do with reality!

The problem of the proposal is that we are not yet able to detect and manipulate dark matter in laboratory for the simple reason that we do not understand it (maybe we do it routinely at the level of biology!).

A. The TGD based conjecture [**?**] is that dark matter as $h_{eff}/h = n$ phases of ordinary matter emerges at quantum criticality. Large h_{eff} would make possible long range quantum fluctuations and correlates by scaling up various quantum lengths typically by h_{eff}/h. Therefore the ability to create and control quantum critical systems would be the prerequisite for the proposed test.

B. Various macroscopic quantum systems are excellent candidates for quantum criticality. Superfluids exhibiting fountain effects apparently defying gravitation could be such systems too [**?**]. Note that gravitational Compton length $\hbar_{gr}/m = GM/v_0$ does not depend on the m at all (this is implied by Equivalence Principle) so that particles with different masses could form gravitationally quantum coherent state.

C. In biology this kind of systems could be created for some critical values of parameters: living system would be almost by definition quantum critical and metabolic energy feed would be necessary to induce quantum criticality since in general the energies of various quantum states are larger for $h_{eff} > h$, in particular atomic binding energies behave like $1/h_{eff}^2$. DNA, proteins, cell membrane, axonal membranes, and microtubules would represent examples of critical systems. Nervous system would be such system in longer length scale.

There was a very interesting link to an article telling about the category theoretical description of topological order [B12] (see `http://tinyurl.com/y9c29yly`). The description of non-Abelian Quantum Hall in terms of patterns of zeros of multi-electron wave function and using so called Z_n current algebra states is considered in [B8].

Topological order means emergence of discrete degrees of freedom implying ground state degeneracy and long range correlations, even long range entanglement. Topological order appears in 2+1-D systems. Braiding and braid statistics characterized by R-matrix are central elements. There is also a connection with integrable 2-D quantum field theories. The generalization of R-matrix defines 2-particle S-matrix defining the building brick of N-particle S-matrix in 2-D integrable quantum field theories: the basic interaction is passing-by inducing a phase lag. For braids the exchange is a continuous homotopy and braiding dynamics could make possible topological quantum computation [K1].

One cannot avoid the feeling that topological order is exactly the mathematical tool needed in quantum TGD. On basis of what I have learned recently [L8, L5] (see `http://tinyurl.com/yafezdrm`) and `http://tinyurl.com/ydc33gcs`), condensed matter physicists might be discovering many-sheeted space-time and exotic effects predicted by quantum TGD without realizing what they are doing! I have believed hitherto that this would be something for elementary particle physicists but they are sunken into the multiverse muds of M-theory landscape.

There are several reasons to believe that the notion of topological order in TGD could be very useful in more concrete formulation of quantum TGD.

A. TGD can be seen as almost topological QFT. 3-D surfaces are by holography equivalent with 4-D space-time surfaces and by strong form of holography equivalent with string world sheets and partonic 2-surfaces. What make this duality possible is super-symplectic symmetry [K15, K14] realizing strong form of holography and quantum criticality realized in terms of hierarchy of Planck constants characterizing hierarchy of phases of ordinary matter identified as dark matter. This hierarchy is accompanied by a fractal hierarchy of sub-algebras of supersymplectic algebra isomorphic to the entire algebra [K52]: Wheeler would talk about symmetry breaking without symmetry breaking.

B. $h_{eff} = n \times h$ hierarchy corresponds to n-fold singular covering of space-time surface for which the sheets of the covering co-incide at the boundaries of the causal diamond (CD), and the n sheets together with superconformal invariance give rise n additional discrete topological degreees of freedom - one has particles in space with n points. Kähler action for preferred extremals reduces to Abelian Chern-Simons terms characterizing topological QFT. Furthermore, the simplest example of topological order - point like particles, which can be connected by links - translates immediately to the collections of partonic 2-surfaces and strings connecting them.

C. There is also braiding of fermion lines/magnetic flux tubes and Yangian product and co-product defining fundamental vertices, quantum groups associated with finite measurement resolution and described in terms of inclusions of hyper-finite factors [K53] .

Number theoretic vision [K52] - in particular adelic physics - is an additional building brick in TGD. It would be nice to see what comes out from the combination of topological order with the hierarchy of algebraic extensions of rationals and associated extensions of p-adic number fields by extending the physics to adelic physics. The existence of this extension must pose powerful constraints on physics.

In this article topological order and its category theoretical description are considered from TGD point of view - category theoretical notions are indeed very natural in TGD framework. The basic finding is that the concepts developed in condensed matter physics (topological order, rough description of states as tangles (graphs imbedded in 3-D space), ground state degeneracy, surface states protected by symmetry or topology) fit very nicely to TGD framework and has interpretation in terms of the new space-time concept. This promises

applications also in the conventional areas of condensed matter physics such as more precise description of solid, liquid, and gas phases.
The following considerations can be blamed to be "just philosophy" since I am not a condensed matter physics and do not try to pretend being computational virtuoso. What I dare argue that TGD allows much more wider perpective than is possible inside the boundaries posed by specialization. My hope is that the reader would realize that TGD provides fascinating challenges and inspiration for theoretical physicist - even those working in condensed matter physics.

9.3 What Does Topological Order Mean?

Topological order is something not describable by local order parameters allowing to characterize different phases by their different symmetries using Landau theory. Fractional Quantum Hall effective is simplest example of this: all phases have the same symmetries. One signature is the existence of several degenerate ground states.
As already noticed, in the fractal Universe of TGD one has a hierarchy of quantum criticalities with levels labelled by $h_{eff} = n \times h$ giving rise to "symmetry breaking without symmetry breaking" in terms of an inclusion hierarchy of isomorphic mutually isomorphic subalgebras of super-symplectic algebra. Could this hierarchy lurk behind the existence of phases with identical symmetries? This hierarchy makes sense also for the ordinary conformal invariance, which is much smaller symmetry than super-symplectic one and replaces AdS/CFT duality with more physical looking duality defined by strong form of holography.
For some reason colleagues have not noticed the possibility of this kind of conformal symmetry breaking. This is not the only rather trivial fact that has escaped the attention of hasty colleagues during last decades. The completely unique role of 4-D space-time, the twistorial uniqueness of $M^4 \times CP_2$ [K48], and the fact that CP_2 codes for standard model symmetries, have also remained un-noticed.
The article *Detecting topological order in a ground state wave function* (see `http://tinyurl.com/y78j4f3v`) by Levin and Wen [B10] gives an idea about what topological order is. The simplest situation in which topological order is encountered, is when one has a set of objects such that each pair can be connected by link. The pair can be characterized by "spin" telling whether its members are connected or not. In condensed matter physics one could have lattice like structure with link between given neighboring points or not. This is very special situation. In principle all possible configurations involving links between objects are possible. One could of course pose additional conditions such as as embedding of the vertices as lattice, restriction of the links to nearest neighbour links, allowance of only single link between members of pair, and some maximum number of links emanating from given object.
What does topological order mean in quantum theory?

A. In topological quantum computation each braid topology defines unitary S-matrix and one has only single braid topology. Topology is still classical and fixed although the dynamics in this fixed topology is quantal.
B. There is however no deep reason to assume localization into a single topology. This mixing could occur already in particle physics. The TGD based explanation of family replication phenomenon [K13] assumes that quantum superpositions of the topologies of partonic 2-surfaces characterized by genus and that CKM matrix reflects different topological mixings for U and D type quarks [K34]. Ground state wave function would be quantum superposition of graph topologies. Even more: for given graph one would have also a superposition of different embeddings to 3-space as tangles characterized by knotting and linking.

One can formally describe the topology in terms of "topological spins".

A. For a quantum graph each topological configuration of the system is quantum superposition of graphs with some pairs of vertices connected by link or not. What is fixed are the vertices. One can assign to each pair "spin" -1/1 telling whether the connecting link is present or not. One could assume that each vertex is connected to at least one vertex to exclude lonely vertices. This gives a large number of graphs and ground state is quantum superposition of these graphs. This brings in the long range quantum entanglement between pairs. Some kind of reference configuration could be a graph in which all objects are connected to every other object once.

B. The embedding of graph to 3-D space gives tangle. Tangle consists of several groups of vertices from which connecting links emerge. By fractality one can also tangles within tangles. Tangle can be characterized by its projection to a suitably chosen plane. In the projection two tangle strands cross and there are two different crossings depending which strand is above which. This defines second spin like variable characterizing tangles.

C. In TGD space-time also 2-braiding is possible. 2-braid can be thought of as an evolution of ordinary knot giving rise to 2-D surface in 4-D space-time. One an have un-knotting or its reversal of knots by a violent manner: the braid strands go simply through each other. Knot invariants are actually constructed by performing this violent un-knotting step by step. A spin like variable telling whether this occurs for a pair of braid strands appearing in 2-knot is needed.

The article (see `http://tinyurl.com/y78j4f3v`) considers a lattice in which links are possible between neighboring lattices points. The ground state is a superposition over all link paths as a state with long range entanglement: the product of spins equals to 1 for all closed loops crossing a given curve since the loops intersect the curve always even number of times (this is where topology shows itself!) Could this kind quantum superposition be the first principle approach when one wants to describe many particle system? Liquid, gas, and solid phases would be of course hugely simplified descriptions in this picture. The basic unpleasant question is obvious: can long links be really thermally stable in standard physics?

9.4 Topological Order And Category Theory

The article (see `http://tinyurl.com/y7qjl4bv`) summarizes the proposal to describe topological order in terms of category theory. In reductionistic approach one decomposes the object to smaller and smaller pieces. In particle physics the actions of symmetries on object characterize the object in terms of quantum numbers. In category theoretical approach one describes the system in terms of its relations with other systems. Relations corresponds to morphisms mathematically and are deduced by studying the interactions with other systems. How particle interacts with the other particles defines what particle is.

At the level of topology the braiding of object with other objects provides this kind of basic morphism. Fusion or stacking with other objects defines second morphism. The integer valued coefficients of fusion telling which quantum objects appear in the stacking of the object with another object provide information about objects via its relations. Fusion has splitting as its reversal. Algebraically product and co-product correspond to these operations and I have proposed that zero energy states as transition amplitudes represents sequences algebraic operations - product and co-product identified essentially as 3-particle vertices - in Yangian algebra closely related to category theoretical approach [K48]. Particle vertices would represent additional morphisms besides braiding.

Category theoretical approach can be made quantitative in terms of integers N_k^{ij} telling the multiplicity for representation k in the fusion of representations i and j and fractionals spins s_i characterizing the braid statistics. The category in question must involve also the counterpart of tensor product since in physics one must engineer more complex systems from simpler ones. One speaks of tensor category.

One can define stacking of topological orders serving as the counterpart for tensor product and making topological orders a monoid. Stacking is not ordinary tensor product since there is some inherent entanglement always present. I dare to guess that a special case of Connes tensor product is in question [K53]. This inherent entanglement eliminates a lot of states from the ordinary tensor product. Stacking is interpreted in condensed matter context as formation of multilayers.

If stacking by a given topological order leaves other topological orders as such, the topological order is trivial. A non-trivial topological order can have an inverse: this is equivalent with having no topological excitations. The inverse of the topological order is obtained by time reversal operation acting as symmetry. Non-invertible topological orders correspond to non-Abelian braid statistics.

The basic result of article does not say at the first glance too much to a non-specialist. *Up to an invertible topological order 2+1-D fermionic/bosonic topological orders with/without symmetry are classified by modular braided fusion categories (BFC) over symmetric BFC, where symmetric BFC describes product state with/without symmetry.*

I understand that symmetric BFC corresponds to invertible topological orders acting via the stacking and not affecting the topological order: this is like multiplying vector with scalar in projective space.

9.5 Category Theoretical Description Of Topological Order In TGD

Much of the philosophy and mathematical building bricks of this vision are shared by quantum TGD. The notions of topological order, stacking, and gapless states represent however something new and are highly interesting concerning the more detailed formulation of quantum TGD. This kind of approach is not all that is needed in TGD but could give the tools needed to build the roughest topological characterization of spinor fields in the "world of classical worlds" (WCW) at many-particle level.

9.5.1 Topological order in TGD

In quantum TGD combinatorial description in terms of graphs would give the roughest topological description of the ground state in terms of partonic 2-surfaces (vertices) and fermionic strings or magnetic flux tubes (links) connecting them. It must be made clear, that topological order in TGD sense means radical deviation from the standard model thinking in which space-time is fixed background. This goes also beyond the descriptive powers of the long length scale limit of string models assuming that space-time serves as arena of dynamics.

There are two basic topological elements besides many-sheetedness: the graph structure characterized by telling which partonic 2-surfaces are connected by strings/flux tubes and the tangle structure present because there exists infinite number of topologically non-equivalent embeddings of the graph to 3-D space. 4-D space-time thus allows richest possible topological order besides gigantic super-symplectic symmetries.

A. The strings/flux tubes could connect different partonic surfaces and also return back to the same partonic 2-surface but at different point carrying fermion number. Strings and flux tubes get knotted and linked in 2+1 di-

mensional situation. The outcome is tangle. If there are only two partonic 2-surface no self-entangling one has braid.

B. For partonic 2-surfaces carrying several fermions also self-tangles are possible and one can have quantum superposition of different self-tangles. Flux tubes of dipole magnetic field serve as an illustration.

C. Also the many-sheeted character of space-time gives additional topological degree of freedom in TGD framework. In TGD Universe even elementary particles are structures with at least two space-time sheets since they consist of a pair of wormhole contacts connecting two space-time sheets and wormhole throats at both sheets are connected by flux tubes carrying monopole flux and fermionic strings. For large values of h_{eff} the size of these structure is scaled up so that one could electrons with size scale of cell! As discussed below, many-sheetedness could correspond to what is called stacking of topological orders.

Topological order defined by links is robust and not affected by thermal fluctuations unless the links are thermally unstable. Thermal stability at high temperatures can be argued to be an ad hoc assumption in standard physics. In TGD framework the thermal stability of long links would be due to the hierarchy of Planck constants $h_{eff} = n \times h$. This could make possible long range quantum entanglement between distant topological spins possible in high temperatures.

What about applications? Can one apply the notion of topological order only to low exotic condensed matter systems at low temperature? TGD suggests that applications are possible even at room temperatures.

A. The distinction between liquids and gases is not really well-understood in text book statistical physics missing strings as fundamental objects so that one has only the point particles - partonic 2-surfaces in TGD - and potential function modelling the interactions between them. Topological order replacing potential function with strings/flux tubes should allow an improved understanding the distinction between fluids and gases.

B. The clusters of water molecules are problematic in the standard model description of water, and are crucial in the physics of living matter (consider only the fourth phase of water discovered by Pollack). The existence of strings connecting partonic 2-surfaces would make the clusters of liquid molecules in TGD framework. There is also a connection with $h_{eff} = n \times h$ hypothesis made rigorous by the hierarchy of quantum criticalities explaining dark matter. The longer the flux tubes defining the link needed for clustering are, the larger the value of h_{eff} must be, and the value of h_{eff} characterizes the length scale in which quantum coherence is present.

C. Reductionist finds it convenient to assume that nuclear physics is totally isolated from the condensed matter physics. There are anomalies challenging this hypothesis. For instance, X rays from Sun with energies in the energy scale of transition energies of heavier ions are found to affect the nuclear decay rates so that they vary periodically with period of year [K31]. Could condensed matter transitions do the same trick?

The claims about cold fusion represents second example [K31] Most main streamers refuse to even consider cold fusion as a possibly real phenomenon. The flux tubes carrying dark quarks with large h_{eff} would bind nucleons to form nuclei and they could be so long as to make possible interactions with condensed matter. They could explain several other anomalies such as the anomalous value of proton radius.

9.5.2 Stacking, time reversal, and gapless states in TGD framework?

Stacking can be seen as a constrained tensor product. It could have several interpretations in TGD framework.

A. Stacking might correspond to a formation of quantum states assignable to many-sheeted structures formed from single sheeted structures? Stacking would occur already as one forms elementary particles as double-sheeted structures. Could it be involved with the formation of n-sheeted coverings associated with $h_{eff}/h = n$ and quantum criticality?

B. Topological condensation of a smaller space-time sheet to a larger space-time sheet might have interpretation in terms of stacking? Topologically condensed space-time sheet cannot be represented as a tensor factor in TGD framework. Can the situation be described as a pair of included and including factors with included factor defining measurement resolution for the including factor? Connes tensor product is indeed associated with the inclusion?

C. Many-sheeted space-time suggests the rather exotic looking possibility that two disjoint space-time sheets can have topologically condensed smaller space-time sheets (like liquid drops of the wall) connected to each other by thin flux tubes not visible in the scale of bigger space-time sheets - entanglement would be a resolution dependent notion. In the scale of the bigger space-time sheet one would have ordinary tensor product without entanglement. In the scale of smaller space-time sheets one would have entanglement: subsystems of un-entangled systems would entangle. This has a direct application in TGD inspired theory of consciousness: subselves (mental images) of self can fuse to stereo mental image shared by the selves although selves do not entangle and remained separate conscious entities [K44].

   Could this be described in the formalism based on categories? Is the notion of resolution inherent to this description? The inclusions of hyper-finite factors can be interpreted in terms of finite measurement resolution, and the description of inclusions indeed involves quantum groups as also topological order. The larger space-time sheet seen in the resolution defined by topological condensed space-time sheets would be characterized by quantum space with fractional quantum dimension resulting by modding out the degrees of freedom of topologically condensed space-time sheets.

D. One can imagine a further interpretation for stacking. Negentropic entanglement between states associated with separated space-time sheets could also give rise to a restricted tensor product [K29]. Negentropic entanglement (NE) can be algebraic such that the coefficients belong to the algebraic extension of rationals characterizing the adele but entanglement probabilities are outside this extension, which encourages the hypothesis that diagonalization is not possible and this kind of NE is stable. NE can also correspond to a projector in which case state function reduction need not lead to an eigen ray since the whole sub-space is eigenspace of density matrix.

Time reversal defines inverse topological order provided one can regard it as a symmetry. For instance, time reversal symmetry protects topological insulator. More generally, one can have symmetry protected topological order SPT (see `http://tinyurl.com/ycjasy6b`), which is actually trivial topological order but without long range entanglement. Symmetry protected states do not lead to emergent fractional charge, fractional statistic, nor emergent gauge gauge theory unlike topological order. In TGD framework the emergent gauge symmetry could be identified as a symmetry associated with the action of included hyperfinite factor, which indeed causes no measurable effects in the resolution used.

Here an interesting delicacy appears. Is its particle physicist's time reversal, which is slightly broken symmetry? Or is it time reversal in the sense of TGD inspired theory of quantum measurement and consciousness bringing in the arrow of time (or thermodynamics)? Time reversal in the latter sense cannot be interpreted as a symmetry. For instance, time reversal in the latter sense involves state function reduction at opposite boundary of CD, which is dynamical and non-deterministic process leading to death of self and its reincarnation as time reversed self. Note that time reversal is not allowed for non-Abelian braid statistics and although Kähler action is abelian the vierbein group of CP_2 is non-Abelian and can give rise to non-Abelian braiding by electroweak gauge group.

Gapless boundary excitations implying ground state degeneracy are also an important part of picture.

A. In the case of topological order they are robust against all local perturbations and protected by topology. Systems described by topological QFTs provide a basic example about non-trivial topological order. In the case of SPTs one has only robustness against local perturbations that do not break symmetries.

B. Super-symplectic algebra provides a concretization of the situation in TGD context. The sub-algebra of supersymplectic algebra with conformal weights, which are $h_{eff}/h = n$-ples of those for entire algebra act as gauge transformations and are thus perturbations, which do not change the state: one could say that there is symmetry protection. This differs from topological protection since not all deformations of 3-surfaces at the ends of space-time at boundaries of CD act like gauge symmetries. Indeed, the remaining generators of super-symplectic algebra act as genuine dynamical symmetries and if the generators with conformal weights $0 \leq k \leq n-1$ create physical states one indeed has finite degeneracy of states (this if the conformal weights of the super-symplectic algebra are integers). This gives just the n-fold degeneracy corresponding to singular n-sheeted covering property of space-time surface. Of course, the is a huge difference: usually one deals with finite-D or even discrete groups whereas super-symplectic group is really huge.

To test TGD one must be able to see the physics of single space-time sheet. The difficulty is that usually this physics is masked experimentally: usually we see only the superposition of effects from several sheets. It is also masked theoretically in the approximation based on the space-time of General Relativity and standard model since it is obtained by replacing many-sheeted space-time by a slightly curved region of Minkowski space involving replacement of induced gauge potentials resp. gravitational fields of space-time sheets with their sum defining the gauge potentials of standard model resp. gravitational field of GRT, replacing partonic 2-surfaces by point like particles, and describing fermionic strings in terms of interaction potentials. Condensed matter physicists might be already occasionally seeing the physics of single space-time sheet.

9.5.3 Category theory and TGD

Category theoretical thinking is part of TGD [K11].

A. In reductionistic approach particles are fundamental building bricks. The idea about an isolated particle must be given up in TGD. The strings connecting partonic 2-surfaces are present from beginning rather than only the partonic 2-surfaces, which are the counterparts of particles in the reductionistic approach. Note that in string models one has strings but no partonic two-surfaces so that one still remains in the framework of reductionism!

This has highly non-trivial implications for the understanding of the formation of gravitational bound states and from TGD point of view the failure of superstring models in long length scales is trivial to understand: superstring description of gravitational interactions makes sense only in Planck length scale: the rest is - not history but - wishful thinking eventually leading to landscape and multiverse [K43](`http://tinyurl.com/y95qojt7`).

B. Zero Energy Ontology (ZEO) [K32, K29] is very category theoretical approach. One gives up the notion of positive energy state in ZEO. Positive energy states are replaced with zero energy states, which are pairs of positive and negative energy states at opposite boundaries of causal diamond (CD) and have opposite quantum numbers. Zero energy state is analogous to event in standard ontology consisting of initial and final state. Object is replaced with a relation between objects, one might say.
Zero energy states are described by M-matrices (M-matrix is expressible as products of square root of density matrix and unitary S-matrix). Dynamics is coded by unitary U-matrix expressible in terms of M-matrices so that states code the dynamics in their representation. ZEO shows its power in TGD inspired theory of consciousness and allows to replace observer as an outsider of the physical world with the notion of self, a conscious entity describable in terms of quantum physics.

10 Deconstruction And Reconstruction In Quantum Physics And Conscious Experience

Deconstruction means roughly putting something into pieces. One could also speak about deconstruction followed by a reconstruction since deconstruction creates the impressions that something is just destroyed. Often deconstruction is thought to involve the reconstruction. This process is applied in deconstructivistic architecture (`http://tinyurl.com/y9quf3x4`) as one can learn by going to Wikipedia and also cubism brings in mind this kind of approach. In this process one organizes typical features of given style in new - one might even say "crazy" manner. There can be even a kind of social interaction between buildings: as if they were communicating by exchanging features.
Postmodernism is a closely related movement and claims that truths are socially constructed: great narratives are dead. Nothing could irritate more physicist who has learned how much mistakes and hard work are needed to distill the truth! Everything does not simply go! On the other hand, one can argue the recent sad state of super string theories and frontier theoretical physics in general suggests that postmodernists are right. Superstrings and multiverse are definitely purely social constructs: they were the only games in the town but now American Mathematical Society warns that super string theoreticians are spoiling the public image of science. Multiverse lived only few years. Certainly one great narrative - the story or reductionism and materialism thought to find its final culmination as M-theory - is dead. It is however nonsense to claim that all great narratives are dead. That telling the alternative great narratives in respected journals is impossible does not mean that they are dead!
But is not wise throw the big ideas of deconstruction and reconstruction away. Rather, one can ask whether they could be made part of a new great narrative about physical world and consciousness.

10.1 Deconstruction And Reconstruction In Perception, Condensed Matter Physics And In TGD Inspired Theory Of Consciousness

Deconstruction and reconstruction appear in the construction of percepts, in condensed matter physics, and are also part of TGD inspired theory of consciousness.

10.1.1 Perception

The very idea of deconstruction in architectural sense is highly interesting from the perspective of both quantum physics and consciousness.
The buildup of our perception involves very concretely deconstruction process. First the sensory input is decomposed into features. Edges, corners, positions, motions analyzed to direction and velocity, colors,... Objects are replaced with collections of attributes: position, motion, shape, surface texture, color,.... Deconstruction occurs at lower cortical layers. After this reconstruction takes place: various kinds of features are combined together through a mysterious looking process of binding - and the outcome is a percept.
Reconstruction can occur also in "wrong" manner. This occurs in hallucinations, delusions, and dreams. Humour is based on association of "wrong" things from different categories together. Synesthesia involves association between different sensory modalities: note with a given pitch have characteristic color or numbers correspond to colors or shapes. I remember an article telling about how subject persons in hypnosis can experience what circle with four corners looks like. Some attribute can be lacking from the reconstruction: person can perceive the car as object but not its motion. Car is there now. Moment later it is here. Nothing between.
Also non-standard reconstructions are possible. Could these non-standard reconstructions define a key aspect of creativity. Could reconstruction represent in some lucky situations new idea rather than hallucination or delusion?
For few years ago I listened a radio document about a professional, who builds soundscapes to movies and learned that the construction of soundscape is deconstruction followed by reconstruction. One starts from natural sounds but as such they are not very impressive: driving by car over some-one does not create any dramatic effect- just "splat" - nothing else. Thisit is so non-dramatic that it can be used to create comic. In order to cure the situation the real sounds are analyzed to features and then reconstructed by amplifying some features and by throwing away the unessential ones. The output sounds much more real than the real input. Of course, actors are masters of this technique and this is why videos about ordinary people doing something funny is like looking autistic ghosts. And if you look at the collection of modules of video game you see modules with name "Aargh", "Auch", "Bangggg", etc..
Association is the neuroscientist's key notion and allows to get an idea about what happens in reconstruction. Reconstruction involves association of various features to form the final percepts. First this process occurs for various sensory modalities. Sensory percepts from various sensory modalities are then combined to full percepts in association regions.
But what associations are at deeper level. What features are? Heretic could ask whether they could correspond to conscious experiences not conscious to us but conscious at lower level. Reader probably noticed that reconstruction-deconstruction took place here: the student is not supposed to ask this question since the theories of consciousness for some funny reason - maybe a pure accident - almost as a rule make the assumption that consciousness has no structure- no selves with subselves with sub-selves with... How these features bind to our conscious percepts? Neuroscience alone cannot tell much about this since it is based on physicalism: "hard problem" serves the articulation of

this problem.
The following considerations represent deconstructions and reconstructions, and I will not explicitly mention when this happens. I just warn the reader. Do not stop reading however!

10.1.2 Condensed matter physics

One must bring in some basic notions of quantum theory if one wants to reduce deconstruction and reconstruction to quantum physics. The key mathematical fact is that in quantum theory each particle in many-particle state corresponds to a tensor factor. This notion is very difficult to eplain without actually having a lecture series about quantum tneory but I can try.

A. The basic idea is that one can build Hilbert spaces by forming their tensor products of them. If you have Hilbert spaces of dimensions n_1 and n_2, the tensor product has dimension $n_1 \times n_2$. Hilbert spaces represent physical systems: say electron and proton. To describe word consisting of proton and electron you from the tensor product of these Hilbert spaces. This is like playing with legos.
   Now I must be honest, I was cheating a little bit. Life is not quite so simple. One can also form bound states of two systems - say hydrogen atom from proton and electron, and the bound states of hydrogen atom represent only a sub-space of the tensor product. Connes tensor product is more exotic example: it represents only a sub-space of the entire tensor product: only certain kind of entangled states for which the composites are strongly correlated are allowed. As a matter fact, gluing the legos together creates strong correlations between them so that it serves as a good analogy for Connes tensor product and tensor product assignable to bound states.

B. Even elementary particles have several degrees of freedom -say spin and charge - to which one can assign Hilbert spaces decomposing formally into tensor product of Hilbert spaces associated with these degrees of freedom. Sub-space of the full tensor product is allowed, and one can purely formally say that elementary particle is a bound state of even more elementary particles. Somewhat like written word having meaning to us consists of letters, which as such represent nothing to us (but could represent something to lower level conscious entities). Could it be possible to apply deconstruction to elementary particles?

Now comes the surprise: condensed matter physicists have discovered deconstruction long time ago!

A. Electron in the valence band of conductor has three kinds of degrees of freeedom labelled by spin, charge and orbital state- state of electron in atom - characterizing the valence band. One can velocity to both spin, charge and orbital state. The state of electron decomposes in purely formal sense to a bound state of spinon, chargon, and holon. The question is whether one could have a situation deconstructing this bound state to its composites moving with different velocities. One would have effectively three particles and quantally three waves moving with same velocity. For free electrons obeying Dirac equation this is not possible. But this could be (and is!) possible in condensed matter. This deconstruction is mathematically like ionizing an atom: ion and electron are the outcome.

B. Instead of single wave motion there can be three free wave motions occurring with different velocities (wave vectors) corresponding to spinon, chargon and holon. In popular articles this process is called "splitting" of electron. This term is optimal choice if the purpose is to create profound mis-understandings in layman reader associating naturally splitting with a geometric process of putting tiny ball into pieces. As already explained,

it is Hilbert space which is decomposed into tensor factors, not a tiny ball. The correlations between factors forced by bound state property are broken in this divorce beteen degrees of freedom.

C. What condensed matter theorist propose is roughly following. The consideration is restricted to effectively one-dimensional systems, call them wires. Atoms along line and electrons at atoms, which can be in conduction bands and give rise to a current. Electron has spin, charge, and orbital degrees of freedom if in conduction band and delocalized and thus shared by the atoms. The spin direction of the electron can vary along wire, and electron can excited to a higher orbital in atom and this exciattion can also vary along wire. These degrees of freedom define tensor factors. Usually these degrees of freedom are bound to single entity free electrons and interacting electrons usually move as a single entity with charge, spin, and orbital excitation.

   The holy trinity of charge, spin, and orbital degrees of freedom can be however split under some circumstances prevailing in condensed matter. The phase of the spinor representing electron can vary along wire and defines wave motion with some velocity/wave vector assignable with the ordinary electric current. The spin of electron can rotate at each point. Also the phase of this rotation can vary along wire so that a wave moving along wire with velocity different from that for charge: this is spin wave having as classical analog the rotation of bicycle pedals. If electron moves in a linear lattice of atoms, the orbital excitation can also vary along the wire and a third wave moving with its own velocity is possible. One has three free particle like entities moving with different velocities! This kind of waves are certainly not possible for the solutions of Dirac equation representing freely moving fermions and particle physicists do not encounter them.

D. These wave motions are different from the wave motions associated with phonons and magnons. For sound it is periodic oscillation for the position of atom, which propagates in sound wave. For magnon it is change of spin direction which propagates and defines a spin 1 collective excitation. Spinon as a quasiparticle has spin 1/2 so that spinon and magnon are different things. Spinon is formal constituent of electron made visible by the condensed matter environment. Magnon is collective excitation of condensed matter system.

   Spin currents provide an example of a situation in which spin and charge currents can flow at different speeds and are becoming important in a new technology known as spintronics. Spin currents have very low resistance and the speculation is that they might relate to high T_c super conductivity.

From the articles that I have seen one might conclude that deconstruction is in practice possible only for effectively 1-dimensional systems. I do not see any obvious mathematical reason why the deconstruction could not occur also in higher-dimensional systems.

It is however true that 1-dimensional systems are very special physically and mathematically ans super string theorists know. Braid statistics replaces ordinary statistics at for them and this brings in a lot of new effects. Furthermore, 2-D integrable gauge theories allow interactions as permutations of quantum numbers and lead to elegant models describing deconstructed degrees of fields as quantum fields in 2-D Minkowski space with interactions reducing to 2-particle interactions describable in terms of R-matrix satisfying the Yang-Baxter equations. It is difficult to say how much the association of deconstruction to 1-D systems is due the fact that they are mathematically easier to handle than higher-D ones.

The rise and fall of superstring models certainly was due to this technical easiness. I learned that the easiest manner to kill the idea that fundamental objects are 3-D was to say that superconformal invariance of super-string

models is lost and the theory is not calculable. It took ineeed long time to realize that super-conformal has huge generalization when space-time is 4-D and embedding space has Minkowski space as its factor. Twistorial considerations fixed the whole scheme uniquely. Theoretician should be patient.

10.1.3 TGD inspired theory of consciousness

The believer in quantum consciousness of course wonders what could be the quantum counterparts of deconstruction and reconstruction. It would seem that analysis and synthesis of the sensory input deconstructs the mental image associated with it to features - simpler fundamental mental images- and reconstruct from these the percept as mental image. What does this correspond at the level of physics?

Before one can really answer one must understand what the quantum physical correlates of mental image are. How mental images die and are born? What features are as mental images? What their binding to sensory percepts does mean physically?

Here I can answer only on my own behalf and to do it I must introduce the basic notions and ideas of TGD inspired theory of consciousness. I will not go to details here because I have done this so many times and just suggest that the reading of some basic stuff about TGD inspired theory of consciousness. Suffice it to list just the basic ideas and notions.

A. Zero energy ontology and causal diamonds and hierarchy of Planck constants assignable to quantum criticality are basic notions. Number theoretic vision is also central. In particular, adelic physics fusing real physics and various p-adic physics as correlates for cognition is also basic building brick.

B. Consciousness theory is generalization of quantum measurement theory constructed to solve the basic problems of ordinary quantum measurement theory: observer becomes self described by physics rather than being outsider of the physical world. Negentropy Maximization Principle (NMP) defines the basic variational principle and state that the negentropy gain in state function reduction is maximal.

   Self hierarchy is the basic notion of TGD inspired theory of consciousness. Self experiences subselves as mental images. Self corresponds to a state function reduction sequence to the same boundary of causal diamond (CD). In standard quantum measurement theory this sequence does not change the state but in TGD framework the state at the opposite boundary of CD and even opposite boundary changes. This gives rise to the experience flow of time having the increases of the temporal distance between the tips of CD as a geometric correlate. Self dies as the first reduction to the opposite boundary takes place and re-incarnates at the opposite boundary as its time reversal. Negentropy Maximization Principle forces it to occur sooner or later. The continual birth and death of mental images supports this view if one accepts the idea about hierarchy. One can also consider identification for what the change of the arrow of time means for mental image.

C. Magnetic bodies carrying dark matter identified as $h_{eff} = n \times h$ phases of ordinary matter define quantum correlates for selves. Magnetic body has hierarchical onion-like structure and it communicates with biological body using dark photons propagating along magnetic flux tubes. EEG and its fractal generalization make both communication from/control of biological body to/by magnetic body. Dark matter hierarchy can be reduced to quantum criticality and this in turn has deep roots in the adelic physics.

What reconstruction could mean in TGD inspired theory of consciousness?

A. The restriction of deconstruction to the degrees of freedom of elementary

particle is un-necessary restrictive. One can consider also larger units such a as molecules, cells, etc.. and their representations using tensor products.

B. Besides bound state formation also negentropic entanglement (NE) allows reconstruction of states which are almost stable with respect to NMP. There are two kinds of NE. which can be metastable with respect to NMP. In the first case density matrix is a projector with n identical eigenvalues. This state can result in a state function reduction since it is an eigenstate of the fundamental observable defined by density matrix. It can also happen that the eigenvalues of density matrix having matrix elements in algebraic extension algebraic extension of rationals characterizing the system in the evolutionary hierarchy do not belong to the extension. One can argue that since diagonalization is not possible in the extension, also state function reduction is impossible without a phase transition extending the extension and identifiable as a kind of evolutionary step.
Both kinds of NEs might be involved. The first option would correspond to a kind of enlightened consciousness since any orthonormal state basis would define eigenstate basis of density matrix. Schrödinger cat would be half alive and half dead or half of X and half of Y, where X and Y are any orthonormal superpositions of alive and dead. For the second option there would be a unique state basis. For instance, cat could be $1/\sqrt{2}$ alive and $1 - 1/\sqrt{2}$ dead. This could correspond to a state of rational mind discriminating between things. If a phase transition bringing in $\sqrt{2}$ takes place, state function reduction makes cat fully alive or dead.

C. In condensed matter example the velocity of quantal wave motion serves as a criterion allowing to tell whether the degrees of freedom bind or not. Electron velocity is obviously too limited as a signature for binding or its absence. In neuroscience the coherence of EEG is seen as a signature of binding and this suggests that oscillation with same EEG frequency is the signature of binding of mental images to a larger one. In TGD inspired theory of consciousness EEG frequencies correspond to differences of generalized Josephson frequencies that is sums of Josephson frequency for the resting potential and of the difference of cyclotron frequencies for ions at different sides of cell membrane [K17, K40, K41].

D. At the level of magnetic flux tubes binding would correspond to a reconnection of magnetic flux tubes of synchronously firing region to form a larger structure for which the magnetic field strength is same for the composites and therefore also cyclotron frequencies are identical. Reconstruction would have a concrete geometric correlate at the level of magnetic flux tubes as reconnection. Different parts of brain containing quantum states serving as features of mental image would connected by flux tubes of the magnetic body and binding of mental images would take place.

E. In TGD inspired quantum biology dark matter identified as large $h_{eff} = n \times h$ phases give rise to a deconstruction if one accepts the hypothesis $\hbar_{eff} = \hbar_{gr} = GMm/v_0$, where M represents mass of dark matter and m particle mass. Here h_{gr} is assigned with a flux tube connecting masses M and m and v_0 is a velocity parameter characterizing the system. This hypothesis implies that dark cyclotron energy is proportional to $h_{gr}f_c$, where f_c is cyclotron frequency is independent of particle mass: universal cyclotron energy spectrum is the outcome. The dark cyclotron photons can transform to ordinary photons identified as bio-photons.
What makes this so remarkable is that particles with magnetic dipole moment possessing different masses correspond to different values of h_{eff} and reside at different magnetic flux tubes. This is mass spectroscopy - or deconstruction of charged particles matter by taking the particles with different masses to their own dark worlds! Dark living matter would not be a random soup of particles: each charged particle (also neutral par-

ticles with magnetic dipole moment) sits neatly at its own shelf labelled by h_{gr}! In TGD inspired theory of consciousness magnetic flux tubes can be associated with magnetic bodies serving as correlates of selves so that deconstruction for mental images would reduce to this process with each charged particle representing one particular combination and perhaps also a quale [K22].

What about re-construction in this framework?

A. In reconstruction flux tube connections between two subsystems representing sub-selves (experienced by self as mental images) would be formed so that they would fuse to single system characterized by the same cyclotron frequency. Flux tube connection would be formed by the reconnection of U-shaped flux tubes to form single pair of connecting flux tubes connecting the systems. Resonant exchange of dark cyclotron photons and also dark super-conductivity would accompany this process. This process would represent a correlate for directed attention and would take place already at bio-molecular level. For instance, I have proposed that biomolecules with aromatic rings in which circulating electron pair currents generate magnetic bodies are especially important and in some sense fundamental level of the self hierarchy at molecular level. In brain different brain regions could connect to single coherently firing region in this manner.

B. The magnetic bodies associated with brain regions representing features could be connected in this manner to larger sub-selves. Negentropic quantum entanglement - a purely TGD based notion - could define a further correlate for the binding. This entanglement could take place in discrete degrees of freedom related to the hierarchy $h_{eff} = n \times h$ of Planck constants having no correlate in standard physics. The discrete degree of freedom would correspond to n sheets of singular coverings representing space-time surfaces. The sheets would co-incide at the ends of causal diamonds (CDs): on possible interpretation (holography allows many of them) could be that entire closed 3-surfaces formed by space-like 3-surfaces and light-like 3-surface connecting them can be seen as basic objects.

C. Reconstruction by negentropic quantum entanglement and flux tube connections inducing resonance could also lead to non-standard composites. Synesthesia could be understood in this manner and even the sensory experience about circle with four corners could be understood. The binding of left and right brain visual experiences to single one could take place through negentropic entanglement and effectively generate the third dimension. The dimensions would not however simply add: 3-D experience instead of 4-D. Could sensory perception of higher than 3-D objects be possible by a reconstruction fusing several visual percepts - maybe even from different brains - together? Could higher levels of self hierarchy carry out this kind of reconstruction? Could Mother Gaia fuse our experiences to single experience about what it is to be a human kind, species, or biosphere?

10.2 Could Condensed Matter Physics And Consciousness Theory Have Something To Share?

Magnetic bodies are present in all scales and one can to ask whether consciousness theory condensed matter physics might have something in common. Could the proposed description apply even at the level of condensed matter? Could construction and reconstruction of mental images identifiable as sub-selves take place already at this level and have interpretation in terms of primitive information processing building standardized primitive mental images?
Deconstruction need not be restricted to electron and velocity could be replaced by oscillation frequency for various fields: at quantum level there is not

actually real distinction since in quantum theory velocity defines wave vector. Also more complex objects, atoms, molecules, etc. could be deconstructed and the process could occur at the level of magnetic bodies and involve in essential manner reconnection and other "motor actions" of flux tubes. The notions of quasi-particle and collective excitation would generalized dramatically and the general vision about basic mechanism might help to understand this zoo of exotics.

Future condensed matter theorists might also consider the possibility of reconstruction in new manner giving rise to the analogs of synesthesia. Could features from different objects be recombined to form exotic quasi-objects having parts all around. Could dark matter in TGD sense be involved in essential manner: could cyclotron resonance or its absence serve as a correlate for the binding. The disjoint regions of space would be in well-defined sense near to each other in the reconstructed state. Topology would be different: p-adic topology could provide a natural description for a situation: in p-adic topology systems at infinite distance in real sense can be infinitesimally close to each other p-adically.

One can build many-particle states free many-particle states using tensor products of these primitive tensor factors. Bound states are clearly new kinds of particle like entities. Under additional constraints one obtains bound states. Could deconstruction in physical sense mean the decomposition of this kind of bound states to effectively free many-particle states? Can one see reconstruction the reversal of these process? And is it possible that tensor factors are combined in a totally new manner somewhat like basic geometric features in deconstructivistic architecture?

REFERENCES

Mathematics

[A1] Yangian symmetry. Available at: `https://en.wikipedia.org/wiki/Yangian`.

[A2] Freed DS. The Geometry of Loop Groups, 1985.

[A3] N. Hitchin. Kählerian twistor spaces. *Proc London Math Soc*, 8(43):133–151, 1981.. Available at: `https://tinyurl.com/pb8zpqo`.

Theoretical Physics

[B1] Vasilyev O Abraham DB, Maciolek A. Emergent Long-Range Couplings in Arrays of Fluid Cells. *Phys Rev Lett*, 113(077204), 2014.

[B2] Zamolodchikov AB Belavin AA, Polyakov AM. Infinite conformal symmetry in two-dimensional quantum field theory. *Nucl Phys B*, 241:333–380, 1984. Available at: `https://users.physik.fu-berlin.de/~kamecke/ps/BPZ.pdf`.

[B3] Marletto C and Vedral V. Witnessing quantumness of a system by observing only its classical features, 2017. Available at `https://tinyurl.com/y8dxe3fa`.

[B4] Marletto C and Vedral V. Witness gravity's quantum side in the lab. *Nature*, 547(7662), 2017. Available at `https://tinyurl.com/ybylck8m`.

[B5] Witten E Dolan L, Nappi CR. Yangian Symmetry in $D = 4$ superconformal Yang-Mills theory, 2004. Available at: `https://arxiv.org/abs/hep-th/0401243`.

[B6] Plefka J Drummond J, Henn J. Yangian symmetry of scattering amplitudes in $\mathcal{N} = 4$ super Yang-Mills theory, 2009. Available at: https://cdsweb.cern.ch/record/1162372/files/jhep052009046.pdf.

[B7] Arkani-Hamed N et al. The All-Loop Integrand For Scattering Amplitudes in Planar N=4 SYM, 2010. Available at: https://arxiv.org/abs/1008.2958.

[B8] Lu Y et al. Non-Abelian Quantum Hall States and their Quasiparticles: from the Pattern of Zeros to Vertex Algebra, 2009. Available at: https://arxiv.org/pdf/0910.3988v2.pdf.

[B9] Strominger A et al. BMS supertranslations and Weinberg's soft graviton theorem, 2014. Available at: https://arxiv.org/abs/1401.7026.

[B10] Weng Z Levin M. Detecting topological order in a ground state wave function, 2007. Available at: https://arxiv.org/pdf/cond-mat/0510613v2.pdf.

[B11] Virasoro MA Mezard M, Parisi G. *Spin Glass Theory and Beyond*. World Scientific, 1987.

[B12] Xiao-Gang Wen Tian Lan. A theory of 2+1d fermionic topological orders and fermionic/bosonic topological orders with symmetries, 2015. Available at: https://arxiv.org/pdf/0903.2083v3.pdf.

Particle and Nuclear Physics

[C1] For one tiny instant, physicists may have broken a law of nature. Sciencedaily 30, 2010.Available at: https://www.sciencedaily.com/releases/2010/03/100329214740.htm.

[C2] Summaries of Widom-Larsen theory. Available at: https://newenergytimes.com/v2/sr/WL/WLTheory.shtml#summary.

[C3] Clemente M et al. *Phys Rev*, 137, 1984.

[C4] Cowan T et al. *Phys Rev*, 54:56, 1985.

[C5] Schweppe J et al. *Phys Rev*, 51.

[C6] Tsertos H et al. *Phys Lett*, 273:326, 1985.

[C7] Holmlid L and Kotzias B. Phase transition temperatures of 405-725 K in superfluid ultra-dense hydrogen clusters on metal surfaces. *AIP Advances*, 6(4), 2016.. Available at: https://tinyurl.com/hxbvfc7.

Condensed Matter Physics

[D1] Skinner B. Repeated noise pattern in the data of arXiv:1807.08572, "Evidence for Superconductivity at Ambient Temperature and Pressure in Nanostructures", 2018. Available at:https://arxiv.org/pdf/1808.02929.pdf.

[D2] Donegan JF Ballantine KE and Eastham PR. There are many ways to spin a photon: Half-quantization of a total optical angular momentum. *Science Advances*, 2(4), 2016.

[D3] Fort E Couder Y. Single particle diffraction in macroscopic scale. *Phys Rev Lett*, 97(154101), 2006. Available at: https://arxiv.org/pdf/1103.0517.pdf.

[D4] Bernien H et al. Probing many-body dynamics on a 51-atom quantum simulator. *Nature*, 551:579–584, 2017.Available at: https://www.nature.com/articles/nature24622.

[D5] Chatterjee S et al. Lifshitz transition from valence fluctuations in YbAl3. *Nature Communications*, 8(852), 2017. Available at: https://www.nature.com/articles/s41467-017-00946-1.

[D6] Eremets MI et al. Superconductivity at 250 K in lanthanum hydride under high pressures. 2018. Available at:https://arxiv.org/abs/1812.01561.

[D7] Li H et al. Coherent organization of electronic correlations as a mechanism to enhance and stabilize high-TC cuprate superconductivity. *Science*, 9(26), 2018. Available at: https://www.nature.com/articles/s41467-017-02422-2.

[D8] Li Y et al. Exact results on itinerant ferromagnetism and the 15-puzzle problem. *Phys Rev. B*, 98(180101(R)), 2018.Available at: https://tinyurl.com/y9ycj3nt.

[D9] Lin X et al. Beating the thermodynamic limit with photo-activation of n-doping in organic semiconductors. *Nature Materials*, 16:1209–1215, 2017.Available at: https://www.nature.com/articles/nmat5027.

[D10] Mi X et al. Observation of Time-Crystalline Eigenstate Order on a Quantum Processor, 2021. Available at: https://arxiv.org/abs/2107.13571.

[D11] Mills R et al. Spectroscopic and NMR identification of novel hybrid ions in fractional quantum energy states formed by an exothermic reaction of atomic hydrogen with certain catalysts, 2003. Available at: https://www.blacklightpower.com/techpapers.html.

[D12] Möttönen et al. Observation of quantum-limited heat conduction over macroscopic distances, 2015. Available at: https://arxiv.org/pdf/1510.03981v1.pdf.

[D13] Plumhof JD et al. Room-temperature Bose Einstein condensation of cavity exciton polaritons in a polymer. *Nature Materials*, 13:247–252, 2013. Available at:https://goo.gl/bZ6LFs.

[D14] Sebastian SE et al. Unconventional fermi surface in an insulating state. *Science*, 349(6243):605–607, 2015. Available at: ttps://en.wikipedia.org/wiki/Pi_bond.

[D15] Turner CJ et al. Quantum scarred eigenstates in a Rydberg atom chain: entanglement, breakdown of thermalization, and stability to perturbations, 2018. Available at:https://arxiv.org/pdf/1806.10933.pdf.

[D16] Hofman DM Hartnoll SA. Generalized lifshitz-kosevich scaling at quantum criticality from the holographic correspondence. *Phys Rev B*, 81(151125), 2010. Available at: https://journals.aps.org/prb/abstract/10.1103/PhysRevB.81.155125.

[D17] Bush JWM. Quantum mechanics writ large, 2015. Available at: http://arxiv.org/pdf/1103.0517.pdf.

[D18] Thapa K and Pandey A. Evidence for Superconductivity at Ambient Temperature and Pressure in Nanostructures, 2018. Available at:https://arxiv.org/abs/1807.08572.

[D19] M kinen JT et al. Mutual friction in superfluid He B3 in the low-temperature regime. *Phys Rev B*, 97(014527), 2018. Available at: https://tinyurl.com/y7dtsdys. .

[D20] Mooney KP Gasparini FM Perron JK, Kimball MO. Coupling and proximity effects in the superfluid transition in ^{4}he dots. *Nature Physics*, 6(6):499 502, 2010.

[D21] Golovko VA. Why does superfluid helium leak out of an open container?, 2012. Available at: https://arxiv.org/pdf/1103.0517.pdf.

Fringe Physics

[H1] Seward C. Ball Lightning Events Explained as Self-stable Spinning High-Density Plasma Toroids or Atmospheric Spheromacs.

[H2] Hudson D. Mono-atomic elements, 2003. Available at: https://www.halexandria.org/dward479.htm.

[H3] Duarte JL. Introducing the Yildiz magnetic motor, 2013. Available at: New Illuminati. https://nexusilluminati.blogspot.fi/2013/06/introducing-yildiz-magnetic-motor.html.

[H4] King MB. Water Electrolyzers and the Zero-Point Energy. *Phys Procedia*, 20:335–445, 2011. Available at: https://www.sciencedirect.com/science/journal/18753892.

[H5] Godin SM Roshchin VV. An Experimental Investigation of the Physical Effects in a Dynamic Magnetic System. *New Energy Technologies*, 1, 2001.

[H6] Allan SD. 35+ Reasons Why I Think Yildiz Magnetic Motor Really Works, 2013. Available at: New Illuminati. https://nexusilluminati.blogspot.fi/2013/06/introducing-yildiz-magnetic-motor.html.

Biology

[I1] Water Memory. Available at: https://en.wikipedia.org/wiki/Water_memory.

[I2] The Fourth Phase of Water: Dr. Gerald Pollack at TEDxGuelphU, 2014. Available at: https://www.youtube.com/watch?v=i-T7tCMUDXU.

[I3] Smith C. *Learning From Water , A Possible Quantum Computing Medium*. CHAOS, 2001.

[I4] Auradou H et al. Turning Bacteria Suspensions into Superfluids. *Phys Rev Lett*, 2015.Available at: https://dx.doi.org/10.1103/PhysRevLett.115.028301.

[I5] Benveniste J et al. Human basophil degranulation triggered by very dilute antiserum against IgE. *Nature*, 333:816–818, 1988.

[I6] Benveniste J et al. Transatlantic transfer of digitized antigen signal by telephone link. *J Allergy and Clinical Immunology*, 99:175, 1989. Available at: https://www.digibio-.com/.

[I7] Carell T et al. A high-yielding, strictly regioselective prebiotic purine nucleoside formation pathway. *Science*, 352(6287):833–836, 2016. Available at:https://science.sciencemag.org/content/352/6287/833.

[I8] Cates et al. Shearing Active Gels Close to the Isotropic-Nematic Transition. *Phys Rev Lett*, 101(0681012), 2008. Available at: https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.101.068102..

[I9] Dunkel J et al. Ferromagnetic and antiferromagnetic order in bacterial vortex lattices, 2015. Available at: https://arxiv.org/abs/1511.05000.

[I10] Ferus M et al. Formation of nucleobases in a miller–urey reducing atmosphere. *PNAS.*, 2017Available at: https://tinyurl.com/kxxc7db.

[I11] Gladfelter AS et al. mRNA structure determines specificity of a polyQ-driven phase separation. *Science*, 12, 2018. Available at: https://science.sciencemag.org/content/early/2018/04/13/science.aar7432.

[I12] Tucci S et al. Evolutionary history and adaptation of a human pygmy population of Flores Island, Indonesia. *Science*, 361(6401):511–516, 2018. Available at: https://science.sciencemag.org/content/361/6401/511.

[I13] Liu L Zhu TF Wang Z, Xu W. A synthetic molecular system capable of mirror-image genetic replication and transcription. *Nature Chem*, 2016. Available at: https://dx.doi.org/10.1038/nchem.2517.

Neuroscience and Consciousness

[J1] Bandyopadhyay A. Experimental Studies on a Single Microtubule (Google Workshop on Quantum Biology), 2011. Available at: https://www.youtube.com/watch?v=VQngptkPYE8.

[J2] Blackman CF. *Effect of Electrical and Magnetic Fields on the Nervous System*, pages 331–355. Plenum, New York, 1994.

[J3] Bandyopadhyay A Ghosh G, Sahu S. Evidence of massive global synchronization and the consciousness: Comment on "Consciousness in the universe: A review of the 'Orch OR' theory" by Hameroff and Penrose. *Phys Life Rev*, 11:83–84, 2014.

[J4] Spottiswoode J. Geomagnetic fluctuations and free response anomalous cognition: a new understanding. *J Parapsychol*, 2002. Available at: https://www.jsasoc.com/docs/JP-GMF.pdf.

Books related to TGD

[K1] Pitkänen M. DNA as Topological Quantum Computer. In *Quantum - and Classical Computation in TGD Universe. https://tgdtheory.fi/tgdhtml/Btgdcomp.html*. Available at: https://tgdtheory.fi/pdfpool/dnatqc.pdf, 2015.

[K2] Pitkänen M. Philosophy of Adelic Physics. In *TGD as a Generalized Number Theory: Part I. https://tgdtheory.fi/tgdhtml/Btgdnumber1.html*. Available at: https://tgdtheory.fi/pdfpool/adelephysics.pdf, 2017.

[K3] Pitkänen M. A Model for Protein Folding and Bio-catalysis. In *TGD and Quantum Biology: Part I. https://tgdtheory.fi/tgdhtml/Bqbio1.html*. Available at: https://tgdtheory.fi/pdfpool/foldcat.pdf, 2023.

[K4] Pitkänen M. About Concrete Realization of Remote Metabolism. In *TGD and Fringe Physics. https://tgdtheory.fi/tgdhtml/Bfreenergies.html*. Available at: https://tgdtheory.fi/pdfpool/remotetesla.pdf, 2023.

[K5] Pitkänen M. About Preferred Extremals of Kähler Action. In *Physics in Many-Sheeted Space-Time: Part I. https://tgdtheory.fi/tgdhtml/Btgdclass1.html*. Available at: https://tgdtheory.fi/pdfpool/prext.pdf, 2023.

[K6] Pitkänen M. About Strange Effects Related to Rotating Magnetic Systems . In *TGD and Fringe Physics. https://tgdtheory.fi/tgdhtml/Bfreenergies.html*. Available at: https://tgdtheory.fi/pdfpool/Faraday.pdf, 2023.

[K7] Pitkänen M. Are dark photons behind biophotons? In *TGD and Quantum Biology: Part I. https://tgdtheory.fi/tgdhtml/Bqbio1.html*. Available at: https://tgdtheory.fi/pdfpool/biophotonslian.pdf, 2023.

[K8] Pitkänen M. Basic Extremals of Kähler Action. In *Physics in Many-Sheeted Space-Time: Part I. https://tgdtheory.fi/tgdhtml/Btgdclass1.html*. Available at: https://tgdtheory.fi/pdfpool/class.pdf, 2023.

[K9] Pitkänen M. Bio-Systems as Conscious Holograms. In *TGD Universe as a Conscious Hologram. https://tgdtheory.fi/tgdhtml/Bholography.html*. Available at: https://tgdtheory.fi/pdfpool/hologram.pdf, 2023.

[K10] Pitkänen M. Bio-Systems as Super-Conductors: Part I. In *Bio-Systems as Self-Organizing Quantum Systems. https://tgdtheory.*

fi/tgdhtml/BbioSO.html. Available at: https://tgdtheory.fi/pdfpool/superc1.pdf, 2023.

[K11] Pitkänen M. Category Theory and Quantum TGD. In *TGD and Hyperfinite Factors. https://tgdtheory.fi/tgdhtml/BHFF.html*. Available at: https://tgdtheory.fi/pdfpool/categorynew.pdf, 2023.

[K12] Pitkänen M. Cold Fusion Again. In *TGD and Nuclear Physics. https://tgdtheory.fi/tgdhtml/Bnucl.html*. Available at: https://tgdtheory.fi/pdfpool/coldfusionagain.pdf, 2023.

[K13] Pitkänen M. Construction of elementary particle vacuum functionals. In *p-Adic Physics. https://tgdtheory.fi/tgdhtml/Bpadphys.html*. Available at: https://tgdtheory.fi/pdfpool/elvafu.pdf, 2023.

[K14] Pitkänen M. Construction of Quantum Theory: Symmetries. In *Quantum TGD: Part I. https://tgdtheory.fi/tgdhtml/Btgdquantum1.html*. Available at: https://tgdtheory.fi/pdfpool/quthe.pdf, 2023.

[K15] Pitkänen M. Construction of WCW Kähler Geometry from Symmetry Principles. In *Quantum Physics as Infinite-Dimensional Geometry. https://tgdtheory.fi/tgdhtml/Btgdgeom.html*. Available at: https://tgdtheory.fi/pdfpool/compl1.pdf, 2023.

[K16] Pitkänen M. Cosmic Strings. In *Physics in Many-Sheeted Space-Time: Part II. https://tgdtheory.fi/tgdhtml/Btgdclass2.html*. Available at: https://tgdtheory.fi/pdfpool/cstrings.pdf, 2023.

[K17] Pitkänen M. Dark Matter Hierarchy and Hierarchy of EEGs. In *TGD and EEG: Part I. https://tgdtheory.fi/tgdhtml/Btgdeeg1.html*. Available at: https://tgdtheory.fi/pdfpool/eegdark.pdf, 2023.

[K18] Pitkänen M. Dark Nuclear Physics and Condensed Matter. In *TGD and Nuclear Physics. https://tgdtheory.fi/tgdhtml/Bnucl.html*. Available at: https://tgdtheory.fi/pdfpool/exonuclear.pdf, 2023.

[K19] Pitkänen M. Does TGD Predict a Spectrum of Planck Constants? In *Dark Matter and TGD: https://tgdtheory.fi/tgdhtml/Bdark.html*. Available at: https://tgdtheory.fi/pdfpool/Planck, 2023.

[K20] Pitkänen M. Expanding Earth Model and Pre-Cambrian Evolution of Continents, Climate, and Life. In *Physics in Many-Sheeted Space-Time: Part I. https://tgdtheory.fi/tgdhtml/Btgdclass1.html*. Available at: https://tgdtheory.fi/pdfpool/expearth.pdf., 2023.

[K21] Pitkänen M. From Principles to Diagrams. In *Quantum TGD: Part III. https://tgdtheory.fi/tgdhtml/Btgdquantum3.html*. Available at: https://tgdtheory.fi/pdfpool/diagrams.pdf, 2023.

[K22] Pitkänen M. General Theory of Qualia. In *TGD Inspired Theory of Consciousness: Part I. https://tgdtheory.fi/tgdhtml/Btgdconsc1.html*. Available at: https://tgdtheory.fi/pdfpool/qualia.pdf, 2023.

[K23] Pitkänen M. Homeopathy in Many-Sheeted Space-Time. In *TGD Universe as a Conscious Hologram. https://tgdtheory.fi/tgdhtml/Bholography.html*. Available at: https://tgdtheory.fi/pdfpool/homeoc.pdf, 2023.

[K24] Pitkänen M. Identification of the WCW Kähler Function. In *Quantum Physics as Infinite-Dimensional Geometry. https://tgdtheory.fi/tgdhtml/Btgdgeom.html*. Available at: https://tgdtheory.fi/pdfpool/kahler.pdf., 2023.

[K25] Pitkänen M. Macroscopic Quantum Coherence and Quantum Metabolism as Different Sides of the Same Coin: Part II. In *TGD Universe as a Conscious Hologram. https://tgdtheory.fi/tgdhtml/Bholography.html*. Available at: https://tgdtheory.fi/pdfpool/molephoto.pdf, 2023.

[K26] Pitkänen M. Magnetic Sensory Canvas Hypothesis. In *TGD and Quantum Biology: Part I. https://tgdtheory.fi/tgdhtml/Bqbio1.html*. Available at: https://tgdtheory.fi/pdfpool/mec.pdf, 2023.

[K27] Pitkänen M. Massless states and particle massivation. In *p-Adic Physics. https://tgdtheory.fi/tgdhtml/Bpadphys.html*. Available at: https://tgdtheory.fi/pdfpool/mless.pdf, 2023.

[K28] Pitkänen M. More Precise TGD View about Quantum Biology and Prebiotic Evolution. In *Evolution in TGD Universe. https://tgdtheory.fi/tgdhtml/Btgdevolution.html*. Available at: https://tgdtheory.fi/pdfpool/geesink.pdf, 2023.

[K29] Pitkänen M. Negentropy Maximization Principle. In *TGD Inspired Theory of Consciousness: Part I. https://tgdtheory.fi/tgdhtml/Btgdconsc1.html*. Available at: https://tgdtheory.fi/pdfpool/nmpc.pdf, 2023.

[K30] Pitkänen M. New Physics Predicted by TGD: Part I. In *p-Adic Physics. https://tgdtheory.fi/tgdhtml/Bpadphys.html*. Available at: https://tgdtheory.fi/pdfpool/TGDnewphys1.pdf, 2023.

[K31] Pitkänen M. Nuclear String Hypothesis. In *TGD and Nuclear Physics. https://tgdtheory.fi/tgdhtml/Bnucl.html*. Available at: https://tgdtheory.fi/pdfpool/nuclstring.pdf, 2023.

[K32] Pitkänen M. Number theoretic vision, Hyper-finite Factors and S-matrix. In *Quantum TGD: Part I. https://tgdtheory.fi/tgdhtml/Btgdquantum1.html*. Available at: https://tgdtheory.fi/pdfpool/UandM.pdf, 2023.

[K33] Pitkänen M. *p-Adic length Scale Hypothesis*. Online book. Available at: https://www.tgdtheory.fi/tgdhtml/padphys.html., 2023.

[K34] Pitkänen M. p-Adic Particle Massivation: Hadron Masses. In *p-Adic Physics. https://tgdtheory.fi/tgdhtml/Bpadphys.html*. Available at: https://tgdtheory.fi/pdfpool/mass3.pdf, 2023.

[K35] Pitkänen M. p-Adic Physics as Physics of Cognition and Intention. In *TGD Inspired Theory of Consciousness: Part II. https://tgdtheory.fi/tgdhtml/Btgdconsc2.html*. Available at: https://tgdtheory.fi/pdfpool/cognic.pdf, 2023.

[K36] Pitkänen M. Quantum Astrophysics. In *Physics in Many-Sheeted Space-Time: Part II. https://tgdtheory.fi/tgdhtml/Btgdclass2.html*. Available at: https://tgdtheory.fi/pdfpool/qastro.pdf, 2023.

[K37] Pitkänen M. Quantum gravity, dark matter, and prebiotic evolution. In *Evolution in TGD Universe. https://tgdtheory.fi/tgdhtml/Btgdevolution.html*. Available at: https://tgdtheory.fi/pdfpool/hgrprebio.pdf, 2023.

[K38] Pitkänen M. Quantum Hall effect and Hierarchy of Planck Constants. In *TGD and Condensed Matter. https://tgdtheory.fi/tgdhtml/BTGDcondmat.html*. Available at: https://tgdtheory.fi/pdfpool/anyontgd.pdf, 2023.

[K39] Pitkänen M. Quantum Mind, Magnetic Body, and Biological Body. In *TGD and Quantum Biology: Part I. https://tgdtheory.fi/tgdhtml/Bqbio1.html*. Available at: https://tgdtheory.fi/pdfpool/lianPB.pdf, 2023.

[K40] Pitkänen M. Quantum Model for Bio-Superconductivity: I. In *TGD and Quantum Biology: Part I. https://tgdtheory.fi/tgdhtml/Bqbio1.html*. Available at: https://tgdtheory.fi/pdfpool/biosupercondI.pdf, 2023.

[K41] Pitkänen M. Quantum Model for Bio-Superconductivity: II. In *TGD and Quantum Biology: Part I. https://tgdtheory.*

fi/tgdhtml/Bqbio1.html. Available at: https://tgdtheory.fi/pdfpool/biosupercondII.pdf, 2023.

[K42] Pitkänen M. Quantum Model for Nerve Pulse. In *TGD and EEG: Part I. https://tgdtheory.fi/tgdhtml/Btgdeeg1.html*. Available at: https://tgdtheory.fi/pdfpool/nervepulse.pdf, 2023.

[K43] Pitkänen M. Recent View about Kähler Geometry and Spin Structure of WCW . In *Quantum Physics as Infinite-Dimensional Geometry. https://tgdtheory.fi/tgdhtml/Btgdgeom.html*. Available at: https://tgdtheory.fi/pdfpool/wcwnew.pdf, 2023.

[K44] Pitkänen M. Self and Binding: Part I. In *TGD Inspired Theory of Consciousness: Part I. https://tgdtheory.fi/tgdhtml/Btgdconsc1.html*. Available at: https://tgdtheory.fi/pdfpool/selfbindc.pdf, 2023.

[K45] Pitkänen M. TGD and Astrophysics. In *Physics in Many-Sheeted Space-Time: Part II. https://tgdtheory.fi/tgdhtml/Btgdclass2.html*. Available at: https://tgdtheory.fi/pdfpool/astro.pdf, 2023.

[K46] Pitkänen M. *TGD and Fringe Physics*. Online book. Available at: https://www.tgdtheory.fi/tgdhtml/freenergy.html., 2023.

[K47] Pitkänen M. TGD View about Coupling Constant Evolution. In *Quantum TGD: Part II. https://tgdtheory.fi/tgdhtml/Btgdquantum2.html*. Available at: https://tgdtheory.fi/pdfpool/ccevolution.pdf, 2023.

[K48] Pitkänen M. The classical part of the twistor story. In *Quantum TGD: Part III. https://tgdtheory.fi/tgdhtml/Btgdquantum3.html*. Available at: https://tgdtheory.fi/pdfpool/twistorstory.pdf, 2023.

[K49] Pitkänen M. The Recent Status of Lepto-hadron Hypothesis. In *p-Adic Physics. https://tgdtheory.fi/tgdhtml/Bpadphys.html*. Available at: https://tgdtheory.fi/pdfpool/leptc.pdf, 2023.

[K50] Pitkänen M. The Relationship Between TGD and GRT. In *Physics in Many-Sheeted Space-Time: Part I. https://tgdtheory.fi/tgdhtml/Btgdclass1.html*. Available at: https://tgdtheory.fi/pdfpool/tgdgrt.pdf., 2023.

[K51] Pitkänen M. Three new physics realizations of the genetic code and the role of dark matter in bio-systems. In *Genes and Memes: Part II. https://tgdtheory.fi/tgdhtml/Bgenememe2.html*. Available at: https://tgdtheory.fi/pdfpool/dnatqccodes.pdf, 2023.

[K52] Pitkänen M. Unified Number Theoretical Vision. In *TGD as a Generalized Number Theory: Part I. https://tgdtheory.fi/tgdhtml/Btgdnumber1.html*. Available at: https://tgdtheory.fi/pdfpool/numbervision.pdf, 2023.

[K53] Pitkänen M. Was von Neumann Right After All? In *TGD and Hyperfinite Factors. https://tgdtheory.fi/tgdhtml/BHFF.html*. Available at: https://tgdtheory.fi/pdfpool/vNeumann.pdf, 2023.

[K54] Pitkänen M. WCW Spinor Structure. In *Quantum Physics as Infinite-Dimensional Geometry. https://tgdtheory.fi/tgdhtml/Btgdgeom.html*. Available at: https://tgdtheory.fi/pdfpool/cspin.pdf, 2023.

[K55] Pitkänen M. What p-Adic Icosahedron Could Mean? And What about p-Adic Manifold? In *TGD as a Generalized Number Theory: Part III. https://tgdtheory.fi/tgdhtml/Btgdnumber3.html*. Available at: https://tgdtheory.fi/pdfpool/picosahedron.pdf, 2023.

Articles about TGD

[L1] Pitkänen M. CMAP representations about TGD, and TGD inspired theory of consciousness and quantum biology. Available at: https://www.tgdtheory.fi/tgdglossary.pdf., 2014.

[L2] Pitkänen M. Geometric theory of harmony. Available at: https://tgdtheory.fi/public_html/articles/harmonytheory.pdf., 2014.

[L3] Pitkänen M. New results about microtubules as quantum systems. Available at: https://tgdtheory.fi/public_html/articles/microtubule.pdf., 2014.

[L4] Pitkänen M. Pollack's Findings about Fourth phase of Water : TGD View. Available at: https://tgdtheory.fi/public_html/articles/PollackYoutube.pdf., 2014.

[L5] Pitkänen M. A new control mechanism of TGD inspired quantum biology. Available at: https://tgdtheory.fi/public_html/articles/qcritmech.pdf., 2015.

[L6] Pitkänen M. Cold Fusion Again . Available at: https://tgdtheory.fi/public_html/articles/cfagain.pdf., 2015.

[L7] Pitkänen M. Direct Evidence for Dark DNA?! Available at: https://tgdtheory.fi/public_html/articles/knockout.pdf., 2015.

[L8] Pitkänen M. Does the Physics of SmB6 Make the Fundamental Dynamics of TGD Directly Visible? 2015.

[L9] Pitkänen M. More Precise TGD Based View about Quantum Biology and Prebiotic Evolution. Available at: https://tgdtheory.fi/public_html/articles/geesink.pdf., 2015.

[L10] Pitkänen M. TGD based model for anesthetic action. Available at: https://tgdtheory.fi/public_html/articles/anesthetes.pdf., 2015.

[L11] Pitkänen M. About Physical Representations of Genetic Code in Terms of Dark Nuclear Strings. Available at: https://tgdtheory.fi/public_html/articles/genecodemodels.pdf., 2016.

[L12] Pitkänen M. Badly behaving photons and space-time as 4-surface. Available at: https://tgdtheory.fi/public_html/articles/photonhalf.pdf., 2016.

[L13] Pitkänen M. Bio-catalysis, morphogenesis by generalized Chladni mechanism, and bio-harmonies. Available at: https://tgdtheory.fi/public_html/articles/chladnicata.pdf., 2016.

[L14] Pitkänen M. Holography and Quantum Error Correcting Codes: TGD View. Available at: https://tgdtheory.fi/public_html/articles/tensornet.pdf., 2016.

[L15] Pitkänen M. Hydrinos again. Available at: https://tgdtheory.fi/public_html/articles/Millsagain.pdf., 2016.

[L16] Pitkänen M. One step further in the understanding the origins of life. Available at: https://tgdtheory.fi/public_html/articles/purineorigin.pdf., 2016.

[L17] Pitkänen M. p-Adicizable discrete variants of classical Lie groups and coset spaces in TGD framework. Available at: https://tgdtheory.fi/public_html/articles/padicgeom.pdf., 2016.

[L18] Pitkänen M. Strong support for TGD based model of cold fusion from the recent article of Holmlid and Kotzias. Available at: https://tgdtheory.fi/public_html/articles/holmilidnew.pdf., 2016.

[L19] Pitkänen M. Artificial Intelligence, Natural Intelligence, and TGD. Available at: https://tgdtheory.fi/public_html/articles/AITGD.pdf., 2017.

[L20] Pitkänen M. Cold fusion, low energy nuclear reactions, or dark nuclear synthesis? Available at: https://tgdtheory.fi/public_html/articles/krivit.pdf., 2017.

[L21] Pitkänen M. DMT, pineal gland, and the new view about sensory perception. Available at: https://tgdtheory.fi/public_html/articles/dmtpineal.pdf., 2017.

[L22] Pitkänen M. Does $M^8 - H$ duality reduce classical TGD to octonionic algebraic geometry? Available at: https://tgdtheory.fi/public_html/articles/ratpoints.pdf., 2017.

[L23] Pitkänen M. Does valence bond theory relate to the hierarchy of Planck constants? Available at: https://tgdtheory.fi/public_html/articles/valenceheff.pdf., 2017.

[L24] Pitkänen M. From RNA world to RNA-tRNA world to RNA-DNA-tRNA world to DNA-RNA-protein world: how it went? Available at: https://tgdtheory.fi/public_html/articles/bioworlds.pdf., 2017.

[L25] Pitkänen M. Life-like properties observed in a very simple system. Available at: https://tgdtheory.fi/public_html/articles/plasticballs.pdf., 2017.

[L26] Pitkänen M. Mysteriously disappearing valence electrons of rare Earth metals and hierarchy of Planck constants. Available at: https://tgdtheory.fi/public_html/articles/rareearth.pdf., 2017.

[L27] Pitkänen M. p-Adicization and adelic physics. Available at: https://tgdtheory.fi/public_html/articles/adelicphysics.pdf., 2017.

[L28] Pitkänen M. Philosophy of Adelic Physics. In *Trends and Mathematical Methods in Interdisciplinary Mathematical Sciences*, pages 241–319. Springer.Available at: https://link.springer.com/chapter/10.1007/978-3-319-55612-3_11, 2017.

[L29] Pitkänen M. Philosophy of Adelic Physics. Available at: https://tgdtheory.fi/public_html/articles/adelephysics.pdf., 2017.

[L30] Pitkänen M. Potential "missing link" in chemistry that led to life on Earth discovered. Available at: https://tgdtheory.fi/public_html/articles/misslinkprebio.pdf., 2017.

[L31] Pitkänen M. Clustering of RNA polymerase molecules and Comorosan effect. Available at: https://tgdtheory.fi/public_html/articles/clusterRNA.pdf., 2018.

[L32] Pitkänen M. Dark valence electrons and color vision. Available at: https://tgdtheory.fi/public_html/articles/colorvision.pdf., 2018.

[L33] Pitkänen M. Dark valence electrons, dark photons, bio-photons, and carcinogens. Available at: https://tgdtheory.fi/public_html/articles/carcinogen.pdf., 2018.

[L34] Pitkänen M. Emotions as sensory percepts about the state of magnetic body? Available at: https://tgdtheory.fi/public_html/articles/emotions.pdf., 2018.

[L35] Pitkänen M. Five new strange effects associated with galaxies. Available at: https://tgdtheory.fi/public_html/articles/3galeffects.pdf., 2018.

[L36] Pitkänen M. Maxwell's lever rule and expansion of water in freezing: two poorly understood phenomena. Available at: https://tgdtheory.fi/public_html/articles/leverule.pdf., 2018.

[L37] Pitkänen M. The Recent View about Twistorialization in TGD Framework. Available at: https://tgdtheory.fi/public_html/articles/smatrix.pdf., 2018.

[L38] Pitkänen M. Cosmic string model for the formation of galaxies and stars. Available at: https://tgdtheory.fi/public_html/articles/galaxystars.pdf., 2019.

[L39] Pitkänen M. Does coupling constant evolution reduce to that of cosmological constant? Available at: https://tgdtheory.fi/public_html/articles/ccevoTGD.pdf., 2019.

[L40] Pitkänen M. Some comments related to Zero Energy Ontology (ZEO). Available at: https://tgdtheory.fi/public_html/articles/zeoquestions.pdf., 2019.

[L41] Pitkänen M. A critical re-examination of $M^8 - H$ duality hypothesis: part I. Available at: https://tgdtheory.fi/public_html/articles/M8H1.pdf., 2020.

[L42] Pitkänen M. A critical re-examination of $M^8 - H$ duality hypothesis: part II. Available at: https://tgdtheory.fi/public_html/articles/M8H2.pdf., 2020.

[L43] Pitkänen M. Is $M^8 - H$ duality consistent with Fourier analysis at the level of $M^4 \times CP_2$? https://tgdtheory.fi/public_html/articles/M8Hperiodic.pdf., 2021.

[L44] Pitkänen M. Negentropy Maximization Principle and Second Law. Available at: https://tgdtheory.fi/public_html/articles/nmpsecondlaw.pdf., 2021.

[L45] Pitkänen M. Some questions concerning zero energy ontology. https://tgdtheory.fi/public_html/articles/zeonew.pdf., 2021.

[L46] Pitkänen M. What could 2-D minimal surfaces teach about TGD? https://tgdtheory.fi/public_html/articles/minimal.pdf., 2021.

[L47] Pitkänen M and Rastmanesh R. The based view about dark matter at the level of molecular biology. Available at: https://tgdtheory.fi/public_html/articles/darkchemi.pdf., 2020.