Quantum criticality and dark matter: part IV

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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. In the fourth part of the chapter about quantum criticality applications, which might be labelled as miscellaneous, are discussed.

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 [K14, K34].

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.

1.1 Miscellanous applications including 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 [C1]. 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 [K2]. The basic finding was that 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 [**?**] (`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 [**?**] (for TGD inspired view see the book [K28] 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 [**?**] (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 [L2]. The TGD inspired model for them [L2] involves magnetic flux tubes at which part of protons in EZ is transferred and forms dark proton sequences- essentially dark protons. There a many way 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 [I3, I4, 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 [K13] 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.

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 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 [L5, L11, L6] 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 [L12] 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.

2.1 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 [L9, L10]. 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 [L7] (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.

2.2 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 [L5, L11]. 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 [K15]. 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 $n = 6$.

2.2.1 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.

1. 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.

2. 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.

3. 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.

4. One has on mass shall condition in momentum space which can be written as

$$(p^2 - M_{op}^2)\Psi = 0 \ . \tag{2.1}$$

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.

5. Mass squared operator is direct sum

$$M_{op}^2 = \oplus_{n^\alpha} m^2(n^\alpha) + K^2 \ . \tag{2.2}$$

$K_{\alpha\beta}^2$ 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 $K_{\alpha\beta}^2$ causes mass squared eigenstates to have different masses.

M_{op}^2 would have for $N = 2$ (ordinary particle and its dark variant with single value of n) the form

$$M_{op}^2 = \left[\begin{array}{cc} m^2 & K^2 \\ \overline{K^2} & m^2 \end{array} \right] \ . \tag{2.3}$$

Note that one K^2 can be also complex.

6. 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

$$\begin{aligned} &(-\Box - M_{op}^2)\Psi = 0 \ , \quad \Box = \oplus_\alpha \Box_{n^\alpha} \ , \\ &\Box_n = n^2\hbar_0^2\Box \ , \qquad\qquad \Box = \partial_t^2 - \partial_x^2 - \partial_y^2 - \partial_z^2 \ . \end{aligned} \tag{2.4}$$

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.

7. 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_{op}^2 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 $F_{n^\alpha}^{\mu\nu}F_{n^\beta,\mu\nu}$ 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.

8. 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:

$$|i,x\rangle = C_{i\alpha} e^{i\frac{p_4\cdot x}{n^\alpha \hbar_0}} |n^\alpha\rangle \ . \tag{2.5}$$

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.

1. 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.

2. S-matrix is obtained by translating the states $|i,t = 0\rangle$ appearing in the identity operator to $(t = L, z = L)$.

$$S = \sum_i |i,t=L\rangle\langle i,t=0| \ . \tag{2.6}$$

3. 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 $|n^\alpha\rangle$:

$$\begin{aligned} &|i,t=0\rangle = C_{i\alpha}|n^\alpha\rangle \quad \rightarrow \qquad\qquad |i,t=L\rangle = C_{i\alpha}U^i_\alpha|n^\alpha\rangle \ , \\ &U^i_\alpha = e^{i\frac{(E_i-p)L}{n^\alpha\hbar_0}} \ , \qquad E_i = \sqrt{p^2+m_i^2} \ . \end{aligned} \tag{2.7}$$

Using this formula one can express S using basis $|n^\alpha|$.

$$\begin{aligned} S &= S_{\alpha\beta}|n^\alpha\rangle\langle n^\beta| \ , \\ S_{\alpha\beta} &= \overline{C}^i_\alpha C_{i\beta} U^i_\alpha \ . \end{aligned} \tag{2.8}$$

Here the summation convention for the repeated index i applies.

What are needed are the oscillation probabilities $P_{\alpha\beta}$.

1. The probabilities that an eigenstate $|n^\alpha\rangle$ transforms to eigenstate $|n^\beta\rangle$ during the travel are given by

$$\begin{aligned} &P_{\alpha\beta} = |S_{\alpha\beta}|^2 = Y_{\alpha\beta ij}U^{ij}_{\alpha\beta} \ , \qquad\qquad Y_{\alpha\beta ij} = \overline{C}_{i\alpha}C_{i\beta}C_{j\alpha}\overline{C}_{j\beta} \\ &U^{ij}_{\alpha\beta} = U^i_\alpha\overline{U^j_\beta} = cos(X^{ij}_{\alpha\beta}) + isin(X^{ij}_{\alpha\beta}) \ , \quad X^{ij}_{\alpha\beta} = \tfrac{(E_i-p)L}{n^\alpha\hbar_0} - \tfrac{(E_j-p)L}{n^\beta\hbar_0} \ . \end{aligned} \tag{2.9}$$

2. One can decompose $P_{\alpha\beta}$ as

$$P_{\alpha\beta} = Re[Y_{\alpha\beta ij}]cos(X^{ij}_{\alpha\beta}) - Im[Y_{\alpha\beta ij}]sin(X^{ij}_{\alpha\beta}) \ , \tag{2.10}$$

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

$$P_{\alpha\beta} = \delta_{\alpha\beta} - 4\sum_{i<j} Re[Y_{\alpha\beta ij}]sin^2(\frac{X^{ij}_{\alpha\beta}}{2}) - 2\sum_{i<j} Im[Y_{\alpha\beta ij}]sin(X^{ij}_{\alpha\beta}) \ . \tag{2.11}$$

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.

3. 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

$$X^{ij}_{\alpha\beta} = \frac{(E_i - p)L}{n^\alpha \hbar_0} - \frac{(E_j - p)L}{n^\beta \hbar_0} \simeq \frac{m_i^2 L}{p n^\alpha \hbar_0} - \frac{m_j^2 L}{p n^\beta \hbar_0} \ . \tag{2.12}$$

4. For given 3-momentum p $P_{\alpha\beta}$ is a sum over $N \times (N-1)$ periodic functions of L with periods

$$\lambda^{ij}_{\alpha\beta} = \frac{2\pi}{X^{ij}_{\alpha\beta}} \ . \tag{2.13}$$

5. 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

$$P_{\alpha\beta} = \delta_{\alpha\beta} - 2Re[Y_{\alpha\beta ij}] \ . \tag{2.14}$$

Some general comments are in order.

1. 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 [K19, K15]. In the case of massless particles the mixing during propagation can however make the mass arbitrarily small as will be found.

2. 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:

$$X^{ij}_{11} = \frac{(E_i - p)L}{\hbar} - \frac{(E_j - p)L}{\hbar} \simeq \frac{(m_i^2 - m_j^2)L}{p\hbar} \ . \tag{2.15}$$

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.

3. 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.

2.2.2 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.

1. The most general form of mass matrix is in the case of single value of n given by $M_{op}^2 = [m^2, K^2; \overline{K^2}, m^2]$. Note that the diagonal element is assumed to be nonvanishing: this allows to avoid tachyonic mass squared eigenstate. The eigen valuels of M_{op}^2 are given by

$$M_\pm^2 = m^2 \pm |K|^2 \quad . \tag{2.16}$$

2. The condition $M_-^2 \geq 0$ gives $m^2 \geq |K|^2$. For the general mass squared matrix $M_{op}^2 = [m_1^2, K^2; \overline{K^2}, m_2^2]$ 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.

3. 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.

2.2.3 Could the mixing with dark photons provide and additional contribution to particle masses?

p-Adic thermodynamics [K15] 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 $x = \sum x_n p^n \rightarrow \sum x_n p^{-n}$ 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.

2.2.4 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

$$D = [\frac{P}{p^2 Id - M^2(op)}]_{ij} = \frac{P}{p^2} \sum_{n \geq 0} [\frac{M^2(op)}{p^2}]^n_{ij} \quad . \tag{2.17}$$

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.

3 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?

3.1 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 [B4] (`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.

3.2 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!

1. 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!

2. 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!

3. 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.

1. 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.

2. 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?

3. 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?

3.3 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.

3.3.1 The basic ideas of TGD relevant for blackhole concept

The basic assumptions/predictions of TGD relevant for the recent discussion are following.

1. 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.

2. 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!

3. 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 hierarchy 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. Superconductivity 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.

4. 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.

5. 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.

6. 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.

3.3.2 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 $1/h_{eff}^2$.

1. 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?

2. 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 [K32] 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 [K29] 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 [K8] 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.

3. 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.

3.3.3 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.

1. 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.

2. 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!).

3. 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.

4. 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.

5. 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.

1. 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 [K22], 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.

2. 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.

3. 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 [K11]. Number theoretically preferred scalings of blackhole radius come as powers of 2 and this would be the scaling associated with Expanding Earth hypothesis.

3.4 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`) [B4] to solve the blackhole information loss problem. In the article Maxwellian electrodynamics is taken as a simpler toy example.

1. 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.

2. 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.

3. 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.

4. 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.

5. 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.

1. 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.

2. 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 natural 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?

1. 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.

2. 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) [K3] 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.

3. 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:

$$j_\Phi^\alpha = J^{\alpha\beta}\partial_\beta\Phi \ , \tag{3.1}$$

   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:

$$j_\Phi^\alpha\partial_\alpha\Phi = 0 \ . \tag{3.2}$$

   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:

$$j_\Phi^\alpha = g^{\alpha\beta}\partial_\beta\Psi \ . \tag{3.3}$$

   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 :

$$j_\Phi^\alpha = kg^{\alpha\beta}\partial_\beta\Psi \ . \tag{3.4}$$

   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.

4. 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

$$Q_{\delta,\Phi} = \oint J^{tn}\Phi g^{1/2} \tag{3.5}$$

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.

5. Besides this there is interior contribution, which is Kähler current multiplied by -Φ:

$$Q_{int,\Phi} = \int j^t \Phi g^{1/2} \quad . \tag{3.6}$$

This contribution is present for MEs.

6. 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.

4 How to demonstrate quantum superposition of classical gravitational fields?

There was rather interesting article in Nature [B2] (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 [B1] (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!).

4.1 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 [B2] 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.

1. 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.

2. 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.

1. 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 [L8, L10].

2. The Planck constant associated with the magnetic flux tube is proportional to the product of corresponding charges at its ends [K10, **?**, K27, K21]. 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.

4.2 Zeno effect and weak measurements

The proposal of Marletto and Vedral [B1, B1] 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.

4.2.1 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.

1. 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 [K31]. This experiment does not however say anything about whether classical gravitational fields form quantum superpositions.

2. 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.

3. 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 [K21].

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?

4.2.2 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.

1. 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.

2. 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.

3. 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

$$\begin{aligned} \Psi(\Delta t)\Phi(\Delta t) &= M_q\Psi(0)\otimes|q\rangle \ , \\ M_q &= \frac{1}{N}\times exp(-ik\Delta t x\otimes p) \ , \\ N &= \sqrt{\langle\Psi(0)|M_q^\dagger M_q|\Psi(0)\rangle} \ . \end{aligned} \tag{4.1}$$

   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

$$M_q = \frac{1}{(2\pi\sigma^2)^{1/4}} exp((-q-x)^2/4\sigma^2) \ . \tag{4.2}$$

   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.

1. 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.

2. 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.

4.2.3 Weak measurement induced by measurement of classical gravitational fields

How could one apply weak measurement to monitor gravitational fields and their quantum superpositions?

1. 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.

2. 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.

4.2.4 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.

1. 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.

2. 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 lifetime 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!).

1. 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.

2. 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.

3. 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 [B6] (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 [B3].

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 [L4, L3] (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.

1. 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 [K7, K6] 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 [K32]: Wheeler would talk about symmetry breaking without symmetry breaking.

2. $h_{eff} = n \times h$ 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.

3. 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 [K33] .

Number theoretic vision [K32] - 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.

4.3 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 $M^4 \times CP_2$ [K30], 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 [B5] 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?

1. 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.

2. 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 [K5] 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 [K20]. 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".

1. 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.

2. 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.

3. 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?

4.4 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 [K30]. 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 [K33]. 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.

4.5 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.

4.5.1 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.

1. 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 dimensional situation. The outcome is tangle. If there are only two partonic 2-surface no self-entangling one has braid.

2. 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.

3. 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.

1. 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.

2. 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.

3. 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 [K17]. Could condensed matter transitions do the same trick?

   The claims about cold fusion represents second example [K17] 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.

4.5.2 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.

1. 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?

2. 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?

3. 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 unentangled systems would entangle. This has a direct application in TGD inspired theory of consciousness: sub-selves (mental images) of self can fuse to stereo mental image shared by the selves although selves do not entangle and remained separate conscious entities [K26].

   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.

4. 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 [K16]. 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 re-incarnation 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.

1. 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.

2. 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.

4.5.3 Category theory and TGD

Category theoretical thinking is part of TGD [K4].

1. 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 [K25](`http://tinyurl.com/y95qojt7`).

2. Zero Energy Ontology (ZEO) [K18, K16] 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.

5 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.

5.1 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.

5.1.1 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!

5.1.2 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.

1. 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.

2. 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!

1. 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.

2. 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.

3. 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.

4. 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.

5.1.3 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.

1. 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.

2. 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.

3. 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?

1. The restriction of deconstruction to the degrees of freedom of elementary particle is unnecessary restrictive. One can consider also larger units such a as molecules, cells, etc.. and their representations using tensor products.

2. 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.

3. 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 [K9, K23, K24].

4. 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.

5. 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 particles 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 [K12].

What about re-construction in this framework?

1. 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.

2. 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.

3. 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 bio-sphere?

5.2 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?

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