

About the Nottale's formula for h_{gr} and the possibility that Planck length l_P and CP_2 length R are identical

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Abstract

Nottale's formula for the gravitational Planck constant $\hbar_{gr} = GMm/v_0$ involves parameter v_0 with dimensions of velocity. I have worked with the quantum interpretation of the formula but the physical origin of v_0 - or equivalently the dimensionless parameter $\beta_0 = v_0/c$ (to be used in the sequel) appearing in the formula has remained open hitherto. In this chapter a possible interpretation based on many-sheeted space-time concept, many-sheeted cosmology, and zero energy ontology (ZEO) is discussed. In ZEO the non-changing parts of zero energy states are assigned to the passive boundary of CD and β_0 should be assigned to it.

There are two measures for the size of the system. The M^4 size L_{M^4} is identifiable as the maximum of the radial M^4 distance from the tip of CD associated with the center of mass of the system along the light-like geodesic at the boundary of CD. System has also size L_{ind} defined defined in terms of the induced metric of the space-time surface, which is space-like at the boundary of CD. One has $L_{ind} < L_H$. The identification $\beta_0 = L_{M^4}/L_H$ does not allow the identification of $L_H = L_{M^4}$. L_H would however naturally corresponds to the size of the magnetic body of the system in turn identifiable as the size of CD.

One can deduce an estimate for β_0 by approximating the space-time surface as Robertson-Walker cosmology expected to be a good approximation near the passive light-like boundary of CD. The resulting formula is tested for planetary system and Earth. The dark matter assignable to Earth can be identified as the innermost part of inner core with volume, which is .01 per cent of the volume of Earth. Also the consistency of the Bohr quantization for dark and ordinary matter is discussed and leads to a number theoretical condition on the ratio of the ordinary and dark masses.

$\beta_0/4\pi$ is analogous to gravitational fine structure constant for $\hbar_{eff} = \hbar_{gr}$. Could one see it as fundamental coupling parameter appearing also in other interactions at quantum criticality in which ordinary perturbation series diverges? Remarkably, the value of G does not appear at all in the perturbative expansion in this region! Could G have several values? This suggests the generalization $G = l_P^2/\hbar \rightarrow G = R^2/\hbar_{eff}$ so that G would indeed have a spectrum and that Planck length l_P would be equal to CP_2 radius R so that only one fundamental length would be associated with twistorialization. Ordinary Newton's constant would be given by $G = R^2/\hbar_{eff}$ with \hbar_{eff}/\hbar_0 having value in the range $10^7 - 10^8$.

The second topic of the chapter relates to the the fact that the measurements of G give differing results with differences between measurements larger than the measurement accuracy. This suggests that there might be some new physics involved. In TGD framework the hierarchy of Planck constants $\hbar_{eff} = n\hbar_0$, $\hbar = 6\hbar_0$ together with the condition that theory contains CP_2 size scale R as only fundamental length scale, suggest the possibility that Newton's constant is given by $G = R^2/\hbar_{eff}$, where R replaces Planck length ($l_P = \sqrt{\hbar G} \rightarrow l_P = R$) and \hbar_{eff}/\hbar is in the range $10^6 - 10^7$. The spectrum of Newton' constant is consistent with Newton's equations if the scaling of \hbar_{eff} inducing scaling G is accompanied by opposite scaling of M^4 coordinates in $M^4 \times CP_2$: dark matter hierarchy would correspond to discrete hierarchy of scales given by breaking of scale invariance. In the special case $\hbar_{eff} = \hbar_{gr} = GMm/v_0$ quantum critical dynamics as gravitational fine structure constant $(v_0/c)/4\pi$ as coupling constant and it has no dependence of the value of G or masses M and m .

In this chapter I consider a possible interpretation for the finding of a Chinese research group measuring two different values of G differing by 47 ppm in terms of varying \hbar_{eff} . Also a model for fountain effect of superfluidity as de-localization of wave function and increase of the maximal height of vertical orbit due to the change of the gravitational acceleration g at surface of Earth induced by a change of \hbar_{eff} due to super-fluidity is discussed. Also Podkletnov effect is considered. TGD inspired theory of consciousness allows to speculate about levitation experiences possibly induced by the modification of G_{eff} at the flux tubes for some part of the magnetic body accompanying biological body in TGD based quantum biology.

1 Introduction

This chapter is about two topics: about the identification of the parameter v_0 with dimensions of velocity appearing in the Nottale's formula for gravitational Planck constant [L13], and about possible TGD explanation for the observed variation of gravitational constant assuming that Planck length l_P is actually CP_2 radius R as the condition that TGD as a TOE has only one fundamental length requires, and that the formula $G = R^2/\hbar_{eff}$ holds true meaning that Newton's constant is different for various levels in dark matter hierarchy [L18].

1.1 About the physical interpretation of the velocity parameter in the formula for the gravitational Planck constant

Nottale's formula [E5] for the gravitational Planck constant $\hbar_{gr} = GMm/v_0$ involves parameter v_0 with dimensions of velocity. I have worked with the quantum interpretation of the formula [K5, K4, K11, K10] but the physical origin of v_0 - or equivalently the dimensionless parameter $\beta_0 = v_0/c$ (to be used in the sequel) appearing in the formula has remained open hitherto. In the following a possible interpretation based on many-sheeted space-time concept, many-sheeted cosmology, and zero energy ontology (ZEO) is discussed.

A generalization of the Hubble formula $\beta = L/L_H$ for the cosmic recession velocity, where $L_H = c/H$ is Hubble length and L is radial distance to the object, is suggestive. This interpretation would suggest that some kind of expansion is present. The fact however is that stars, planetary systems, and planets do *not* seem to participate cosmic expansion. In TGD framework this is interpreted in terms of quantal jerk-wise expansion taking place as relative rapid expansions analogous to atomic transitions or quantum phase transitions. The TGD based variant of Expanding Earth model assumes that during Cambrian explosion the radius of Earth expanded by factor 2 [L17] [L17, L16, L19].

There are two measures for the size of the system. The M^4 size L_{M^4} is identifiable as the maximum of the radial M^4 distance from the tip of CD associated with the center of mass of the system along the light-like geodesic at the boundary of CD. System has also size L_{ind} defined in terms of the induced metric of the space-time surface, which is space-like at the boundary of CD. One has $L_{ind} < L_{M^4}$. The identification $\beta_0 = L_{M^4}/L_H < 1$ does not allow the identification $L_H = L_{M^4}$. L_H would however naturally corresponds to the size of the magnetic body of the system in turn identifiable as the size of CD.

One can deduce an estimate for β_0 by approximating the space-time surface near the light-cone boundary as Robertson-Walker cosmology, and expressing the mass density ρ defined as $\rho = M/V_{M^4}$, where $V_{M^4} = (4\pi/3)L_{M^4}^3$ is the M^4 volume of the system. ρ can be expressed as a fraction ϵ^2 of the critical mass density $\rho_{cr} = 3H^2/8\pi G$. This leads to the formula $\beta_0 = \sqrt{r_S/L_{M^4}} \times (1/\epsilon)$, where r_S is Schwarzschild radius.

This formula is tested for planetary system and Earth. The dark matter assignable to Earth can be identified as the innermost part of inner core with volume, which is .01 per cent of the volume of Earth. Also the consistency of the Bohr quantization for dark and ordinary matter is discussed and leads to a number theoretical condition on the ratio of the ordinary and dark masses.

$\beta_0/4\pi$ is analogous to gravitational fine structure constant for $h_{eff} = h_{gr}$. Could one see it as fundamental coupling parameter appearing also in other interactions at quantum criticality in which ordinary perturbation series diverges? Remarkably, the value of G does not appear at all in the perturbative expansion in quantum critical phase! Could G can have several values?

There is also a problem: the twistorialization of TGD [K16] leads to the conclusion that the radius of twistor sphere for M^4 is given by Planck length l_P so that - contrary to the view held for decades - one would have two fundamental lengths - l_P and CP_2 radius R and there is no idea about how they are related. Quantum criticality cannot relate them since they are not coupling parameters.

The formula for $G = l_p^2/\hbar$ however suggests a generalization $G = R^2/h_{eff}$ with h_{eff}/h_0 having value in the range $10^7 - 10^8$: one would have $l_P = R$! Also classical gravitation could tolerate the spectrum of G since Newton's equations in gravitational field is invariant under scaling $h_{eff} \rightarrow xh_{eff}$ inducing $G \rightarrow G/x$ and $t \rightarrow t/x, r \rightarrow r/x$ with scales up the size scale of space-time sheets as the proportionality of Compton length to h_{eff} requires.

1.2 Is the hierarchy of Planck constants behind the reported variation of Newton's constant?

Nowadays it is fantastic to be a theoretical physicists with a predictive theory. Every week I get from FB links to fascinating experimental findings crying for explanation (I am grateful for people providing these links). The last link of this kind was to a popular article (see <http://tinyurl.com/ya2wekch>) telling about the article [E6] (see <http://tinyurl.com/yanvzxj6>) reporting measurements of Newton's constant G carried out by Chinese physicists Shan-Qing Yang, Cheng-Gang Shao, Jun Luo and colleagues at the Huazhong University of Science and Technology

and other institutes in China and Russia. The outcomes of two experiments using different methods differ more than the uncertainties in the experiments, which forces to consider the possibility that G can vary.

1.2.1 The experiments

The experiments use torsion pendulum: this method was introduced by Henry Cavendish in 1778.

Remark: A remark about terminology is in order. Torque $\tau = F \times r$ on particle has dimensions Nm. Torsion (see <http://tinyurl.com/q8esymu>) in solid is essentially the density of torque per volume and has dimensions N/m². Twist angle is induced by torsion in equilibrium. The situation is governed by the theory of elasticity.

Basically one has torsion balance in which the gravitational torque produced by two source masses on masses associated with a torsion pendulum - dumbbell shaped system having identical masses at the ends of a bar and hanging from a thread at the middle point of the bar. As the source masses are rotated a twist of the thread emerges and twist angle corresponds to an equilibrium in which the torsion of the thread compensates the torque produced by gravitational interaction with source masses. Cavendish achieved 1 per cent accuracy in his measurements.

Refined variations of these measurements have been developed during years and the current precision is 47 parts per million (ppm). In some individual experiments the precision is 13.7 ppm. Disagreements larger than 500 ppm are reported, which suggests that new physics might be involved.

The latest experiments were made by the above mentioned research group. Two methods are used. TOS (Time Of Swing) and AAF (Angular Acceleration Feedback). AAF results deviates from the accepted value whereas TOS agrees. The accuracies were 11.64 ppm and 11.61 ppm in TOS and AAF respectively. AAF however gave by 45 ppm larger value of G .

In TOS technique the pendulum oscillates. The frequency of oscillation is determined by the positions of the external masses and G can be deduced by comparing frequencies for two different mass configurations. There are two equilibrium positions. The pendulum is either parallel to the line connecting masses relatively near to each other ("near" position). The pendulum orthogonal to the line connecting masses in "far" position. By measuring the different oscillation frequencies one can deduce the value of G .

Angular-acceleration feedback (AAF) method involves rotating the external masses and the pendulum on two separate turn tables. Twist angle is kept zero by changing the angular velocity of the other turn table: thus feedback is involved. If I have understood correctly, the torsion induced by gravitational torque compensates the torsion created by twisting of the thread around its axis in opposite direction and from the value of torsion for zero twist angle one deduces G . One could perhaps say that in AAF torsion is applied actively whereas in TOS it appears as reaction.

Why the measured value obtained for G would be larger for AAF? Could the active torsion inducing compensating twisting of the torsion pendulum actually increase G ?

1.2.2 A possible TGD explanation for the variation of G

In TGD framework the hierarchy of Planck constants $h_{eff} = nh_0$, $h = 6h_0$ together with the condition that theory contains CP_2 size scale R as only fundamental length scale, suggest the possibility that Newton's constant is given by $G = R^2/h_{eff}$, where R replaces Planck length ($l_P = \sqrt{\hbar G} \rightarrow l_P = R$) and \hbar_{eff}/\hbar is in the range $10^6 - 10^7$. The spectrum of Newton's constant is consistent with Newton's equations if the scaling of h_{eff} inducing scaling G is accompanied by opposite scaling of M^4 coordinates in $M^4 \times CP_2$: dark matter hierarchy would correspond to discrete hierarchy of scales given by breaking of a continuous scale invariance to a discrete one.

In the special case $h_{eff} = h_{gr} = GMm/v_0$ - gravitational Planck constant originally introduced by Nottale [E5]- assignable to quantum critical dynamics gravitational fine structure constant $\alpha_{gr} = GMm/(4\pi\hbar_{gr}) = (v_0/c)/4\pi$ serves as coupling constant and has no dependence of the value of G or masses M and m in accordance with the universality of quantum critical dynamics.

In this chapter I consider a possible interpretation for the finding of a Chinese research group measuring two different values of G differing by 47 ppm in terms of varying h_{eff} . Also a model for fountain effect of superfluidity as de-localization of wave function and increase of the maximal height of vertical orbit due to the change of the gravitational acceleration g at surface of

Earth induced by a change of h_{eff} due to super-fluidity is discussed. Also Podkletnov effect is considered. TGD inspired theory of consciousness allows to speculate about levitation experiences possibly induced by the modification of G_{eff} at the flux tubes for some part of the magnetic body accompanying biological body in TGD based quantum biology.

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A generalization of the Hubble formula $\beta = L/L_H$ for the cosmic recession velocity, where $L_H = c/H$ is Hubble length and L is radial distance to the object, is suggestive. This interpretation would suggest that some kind of expansion is present. The fact however is that stars, planetary systems, and planets do *not* seem to participate cosmic expansion. In TGD framework this is interpreted in terms of quantal jerk-wise expansion taking place as relative rapid expansions analogous to atomic transitions or quantum phase transitions. The TGD based variant of Expanding Earth model assumes that during Cambrian explosion the radius of Earth expanded by factor 2 [L17] [L17, L16, L19].

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2.1 Formula for the gravitational Planck constant and some background

The formula

$$h_{gr} = \frac{GMm}{v_0} \quad (2.1)$$

for the gravitational Planck constant was originally introduced by Nottale [E5]. Here v_0 is a parameter with dimensions of velocity.

The formula is expected to hold true at the magnetic flux tubes mediating gravitational interaction and obeying also the general formula

$$h_{gr} = h_{eff} \quad , \quad h_{eff} = nh_0 \quad , \quad h = 6h_0 \quad . \quad (2.2)$$

The support for the formula $h = 6h_0$ is discussed in [L4, L15]. The value of h_{gr} can be very large unlike the value of h_{eff} associated with say valence bonds.

There are two kinds of flux tubes - homologically non-trivial and trivial ones corresponding to two kinds of geodesic spheres of CP_2 , and they seem to correspond to small and large values of h_{eff} .

1. Since the Kähler magnetic energy of homologically non-trivial flux tubes carrying monopole magnetic flux is large, the natural expectation is that gravitation and presumably also other long range interactions mediated by massless particles - with color interactions perhaps forming an exception - correspond to homologically trivial flux tubes for which only the volume energy due to cosmological constant is non-vanishing. Massive particles would correspond to flux tubes carrying monopole magnetic flux associated with homologically non-trivial flux tubes. Homology could therefore define a key difference between massive and massless bosons at space-time level.
2. One can argue the flux tubes accompanying flux tubes with non-trivial homological charge are relatively short: since the length of the flux tube is expected to be proportional to h_{eff} or its positive power, this would suggest small values of h_{eff} for them. For instance, valence bonds for which non-standard value of h_{eff} is suggestive could correspond to relatively flux tubes carrying monopole flux [L8].
3. Suppose that the value of exponent of Kähler function for the “world of classical worlds” (WCW) is exponent of Kähler function expressible as the 6-D variant of Kähler action for the twistor lift of 4-D Kähler action reducing to the sum of 4-D Kähler action and volume term in the dimensional reduction of the 6-surface to S^2 bundle over space-time surface required by the induction of twistor structure [K14, K16, K12]. If so, the shortness of homologically non-trivial flux tubes could be forced by the large values of Kähler magnetic action and energy making the exponent small.

2.2 A formula for β_0 from ZEO

I have made some attempts relate the value of $\beta_0 = v_0/c$ appearing in the formula for h_{gr} to some typical rotation velocity in the system [K5, K4] but although orders of magnitude are reasonable, these attempts have not led to a prediction of v_0 . It might be that the explanation is hidden at deeper level and involves many-sheeted space-time and the view about quantum theory based on zero energy ontology (ZEO) in an essential manner.

A generalization of the Hubble formula $\beta = L/L_H$ for the cosmic recession velocity, where $L_H = c/H$ is Hubble length and L is radial distance to the object, is suggestive. Some kind of expansion suggests itself. The fact is however that stars, planetary systems, and planets do *not* seem to participate cosmic expansion. In TGD framework this is interpreted in terms of quantal jerk-wise expansion taking place as relative rapid expansions analogous to atomic transitions or quantum phase transitions. The TGD based variant of Expanding Earth model assumes that during Cambrian explosion the radius of Earth expanded by factor 2 [L17] [L17, L16, L19].

The interpretation of the velocity parameter β_0 to be discussed involves in an essential manner ZEO based quantum measurement theory giving rise to a quantum theory of consciousness [L11]. The causal diamond CD assignable to given conscious entity expands state function reduction by state function and this expansion is very much analogous to cosmic expansion.

In TGD inspired theory of consciousness, which is essentially quantum measurement theory in ZEO [L11], self as a conscious entity corresponds to a sequence of analogs of weak measurements changing the members of state pairs at active boundary of CD and increasing the size of CD by shifting the active boundary farther away from the passive boundary. Passive boundary and the members of state pairs at it remain invariant. This produces a generalized Zeno effect leaving both passive boundary and states at it invariant. This gives the unchanging contribution to the consciousness that one might call “soul”. Experienced time corresponds to the increasing distance between the tips of CD and experienced time to the sequence of weak measurements. Active boundary gives rise to changing part in the contents of consciousness. Self dies and reincarnates in opposite time direction when the big state function reduction changing the roles of the boundaries of CD occurs and CD begins to increase in opposite time direction.

To make progress one must consider more precisely what space-time as 4-surface property means in ZEO. The unchanging part of the consciousness corresponds to the passive light-like boundary of CD and various constant parameters should be assigned with the quantum state at it.

There are two measures for the size of the system at the passive boundary and also a measure for the size of its magnetic body mediating gravitational interactions.

1. One can identify M^4 size L_{M^4} as the maximum of the radial M^4 distance from the tip of CD associated with center of mass of the system to the boundary of the system along the light-like geodesic at the passive boundary of CD.
2. System has also size L_{ind} defined as the maximum distance in the induced metric of the space-time surface, which is space-like at the boundary of CD. L_{ind} cannot correspond to Hubble length L_H since this would give $\beta > 0$.
3. A reasonable option is that L_H corresponds to the size scale of the part of the magnetic body of the system responsible for mediation of gravitational interactions. L_H would thus correspond to effective range of gravitational interactions. The simplest guess is that L_H corresponds the maximal radial size of CD given as $L_H = T/2$, where T is the temporal distance between the tips of the CD.

One can deduce an estimate for β_0 by approximating the space-time surface near the passive boundary of CD as Robertson-Walker cosmology. This approximation is indeed natural since space-time surface is small deformation of future/past light-cone near the boundary. The assumption about RW cosmology is *not* needed elsewhere inside CD. This conforms with the holography.

This estimate is only an approximation involving the ratio $\epsilon^2 = \rho/\rho_{cr} < 1$ of the average mass density ρ to the critical mass density

$$\rho_{crit} = \frac{3H^2}{8\pi G}$$

besides H . One can consider at least two options.

1. Option I: ρ corresponds to the average density $\rho = M/V_{M^4}$ within M^4 volume $V_{M^4} = (4\pi/3)L_{M^4}^3$ at the passive boundary. The condition $\rho = \epsilon^2\rho_{cr}$ allows to solve $\beta = L/L_H$ as

$$\beta_0 = \frac{L_{M^4}}{L_H} = \frac{1}{\epsilon} \sqrt{\frac{r_S}{L_{M^4}}} , \quad r_S = 2GM . \quad (2.3)$$

Here r_S is Schwarzschild radius. As noticed, a reasonable identification for L_H would be as the size scale of the gravitational magnetic body given by the size $L_H = T/2$. It turns that this formula is rather reasonable and consistent with earlier results in the case of planetary system and Earth.

2. Option II gives up completely the attempt to interpret the situation in terms of Hubble constant and identifies $\beta_0 = L_{ind}/L_{M^4} < 1$. In this case the expression in terms of mass density in terms of critical mass density does not help to obtain a more detailed formula. If one requires consistency with the previous formula, one obtains L_{ind} as pr $L_{ind} = \sqrt{r_S L_{M^4}}/\epsilon$. For $\epsilon = 1$ one has geometric mean.

2.3 Testing the model in the case of Sun and Earth

One can test these equations for Sun and Earth to see whether they could make sense. The restriction to the option I with volume V identified as the volume in the induced metric at the passive boundary of CD. Option II is obtained at the limit $\epsilon_1 = 1$.

Consider first Sun.

1. In the case of Sun the model for the Bohr quantization of planetary orbits was originally proposed by Nottale [E5] and was developed further in TGD framework in [K5, K4] assuming that genuine quantum coherence in astrophysical scales possible for dark matter is in question. The value of β_0 is in a reasonable approximation $\beta_0(\text{inner}) = 2^{-11}$ for the inner planets and $\beta_0(\text{out}) = \beta_0(\text{inner})/5$ for the outer planets.
2. For the 3 inner planets the distance of Earth given by astronomical unit $AU = .149 \times 10^9$ km is the natural estimate for L_H so that one has $L_H = AU$. For outer planets the natural choice is of the order of the orbit of the outer planet with largest orbital radius, which is Neptune with distance of 30 AU for Neptune. The prediction of the model for the orbital radius of Neptune is 25 AU so that the estimate looks reasonable. Note that the radii in Bohr model are proportional to $h_{gr}^2 n^2$, n the principal quantum number, so that the scaling $v_0 \rightarrow v_0/5$ scales the radius by factor 5². This also means that scaling $n \rightarrow kn$ and scaling $v_0 \rightarrow v_0/k$ produces the same scaled orbital radius.
3. For the inner planets one obtains

$$\beta_0 = \frac{r_S}{L_H} \times \frac{1}{\epsilon} = 1.1 \times 10^{-4} \times \frac{1}{\epsilon} .$$

The value co-incides with $\beta_0 = 2^{-11}$ providing a reasonable approximation in Nottale model for $r = 4.55$. This leaves open the fraction $\epsilon^2 = \rho/\rho_{crit}$. One would have $\epsilon^2 = .048$. The size scale of CD would be about $1/\beta = 2^{11}$ using AU as a unit.

Consider next Earth. One can consider two choices for L .

1. Case I: Earth radius $R_E = 6.371 \times 10^3$ km is the first candidate: this choice might be relevant for the applications at Earth's surface such as fountain effect in super-fluidity.
2. Case II: The distance $d_M = 60.3R_E$ of Moon, is second choice for the scale L . The Schwarzschild radius of Earth is $r_S = 9$ mm.

The value of β_0 in these two cases is given by.

$$\begin{aligned} \beta_0(I) &= \sqrt{\frac{r_S}{R_E}} \frac{1}{\epsilon} = .38 \times 10^{-4} \frac{1}{\epsilon} , \\ \beta_0(II) &= \sqrt{\frac{r_S}{d_M}} \frac{1}{\epsilon} = .04 \times 10^{-4} \frac{1}{\epsilon} . \end{aligned}$$

The condition $\beta_0(I) = 2^{-11}$ is marginally consistent with the biology related considerations of [L14] and requires $r = 13.16$. The size of the CD would be about $2^{11}R_E$ for option I.

For the same value of r for both I and II one has $\beta(I) = 7.76\beta(II) \simeq 8\beta(II)$ so that option II could be obtained from option I by the scaling $\beta(I) \rightarrow \beta/8$ inducing the scaling $R_E \rightarrow 64R_E > 60.3R_E$. By the proportionality of Bohr orbit radius to $1/\beta^2$, the ratio $r(II)/r(I) = \sqrt{64/60.33} = 1.030$ would compensate this error. The mass mass of the moon is $M_M = .012M_E$ so that the replacement of M_E with the $M_E + M_M$ would produce correction factor 1.012 which is by 2 per cent smaller than the required correction factor.

2.4 Under what conditions the models for dark and ordinary Bohr orbits are consistent with each other?

Under what conditions the Bohr orbitologies for dark and ordinary matter are consistent with each other?

1. The condition $v^2 = GM/r$ determines the relationship between velocity and radius in Newtonian theory. The values of v and r cannot therefore change for ordinary matter, which must coupled to all matter - both ordinary and dark matter of the central system.
2. A natural assumption is that dark matter couples only to the dark matter within the volume closed by its orbit. If dark object corresponds to an object modellable as point-like object (the alternative option is that dark matter is along a closed flux tubes along Bohr orbit) then the above condition reads $v_D^2 = GM_D/r$ so that one has

$$\frac{v_D}{v} = \sqrt{\frac{M_D}{M}} . \quad (2.4)$$

There seems to be no reason why the velocities of dark matter and ordinary matter could not be different. In the case of dark matter there is also Bohr orbit condition giving for gravitational Bohr radius as a generalization of $a_0 = \hbar/\alpha m_e \rightarrow a_{gr} = \hbar_{gr}/\alpha_{gr} m$ with $\alpha = e^2/4\pi\hbar \rightarrow \alpha_{gr} = GMm/4\pi\hbar_{gr} = v_0/4\pi$. This gives

$$a = a_{gr,D} n_D^2 , \quad a_{gr} = \frac{4\pi GM_D}{v_0^2} . \quad (2.5)$$

This formula should be consistent with the formula originally derived for matter and motivated by the idea that ordinary matter forms bound states with dark matter. I have considered also the option that dark matter is delocalized along the flux tube associated with the orbit of the planet.

3. The two formulas make sense simultaneously only if one can interpret the Bohr orbit for M_D as Bohr orbit for M having same radius. This condition gives $M_D n_D^2 = M n^2$ giving

$$n_D^2 = \frac{M}{M_D} n^2 . \quad (2.6)$$

Therefore M/M_D should be square of integer, which is rather strong constraint.

One can test this formula in the case of planetary system and for Earth.

1. The first guess is that the inner core of Sun with radius in the range $.2R_S$ and $.25R_S$ corresponds mostly to dark matter. Solar core contains about 34 cent of solar mass (see <http://tinyurl.com/nrcojr2>). This gives in excellent approximation $M/M_D = 3$, which is however not square. $M/M_D = 4$ would satisfy the condition and would have $n_D = 2n$.

Since dark matter corresponds to extensions of rationals, one can ask whether one could allow for dark matter algebraic integers as values of n_D so that $n_D = \sqrt{3}n$ would be allowed for an extension containing $\sqrt{3}$. This would be a number theoretic generalization of quantization in terms of in terms of integers somewhat analogous to that associated with quantum groups.

2. For Earth the estimate [L14] gives $M/M_D \simeq .5 \times 10^4$ giving $\beta_0 = 4.4 \times 10^{-4}$ rather near to $\beta_0 = 2^{-11} \simeq 5 \times 10^{-4}$. It is enough to find integer sufficiently near to 5000 having the property that it is square. One has $70^2 = 4900$ and $71^2 = 5041$.

One would have $n_D \simeq 5000 \times n$ and consistency with the formula. Earth has outer core occupying 15 cent of its volume, inner core occupying 1 cent of the volume and innermost inner core with radius 300 km occupying fraction 10^{-4} of the volume (see <http://tinyurl.com/y8vf7vc3>) suggests that the innermost inner core consists of dark mass with density twice the average density.

Remark: I have considered for M_D a probably too science fictive identification in terms of possibly existing gravitational analog of Dirac monopole. The gravitational flux would emanate radially from the center of the Earth along flux tubes carrying magnetic monopole

flux and turn back at certain distance and return back along second space-time sheet and back to the original space-time sheet at wormhole like structure. This field would not be visible at large enough distances.

If one has $M_D = 2 \times 10^{-4} M_E$, the density of the innermost inner core would be 2ρ , where ρ is the average density of Earth. From Wikipedia (see <http://tinyurl.com/ma6xqnh>) one learns that the average density ρ_E of Earth is $5.52 \times \rho_W$, $\rho_W = \text{kg/dm}^3$ and the density in the inner core varies in the range $\rho/\rho_w \in [12.6 - 13.0]$. The lower limit is approximately $2 \times \rho$. This suggests that the density of the innermost inner core is somewhat larger than 2ρ .

2.5 How could Planck length be actually equal to much larger CP_2 radius?!

The following argument stating that Planck length l_P equals to CP_2 radius R : $l_P = R$ and Newton's constant can be identified $G = R^2/\hbar_{eff}$. This idea looking non-sensical at first glance was inspired by an FB discussion with Stephen Paul King.

First some background.

1. I believed for long time that Planck length l_P would be CP_2 length scale R squared multiplied by a numerical constant of order $10^{-3.5}$. Quantum criticality would have fixed the value of l_P and therefore $G = l_P^2/\hbar$.
2. Twistor lift of TGD [K14, K12, K16, K17] led to the conclusion that that Planck length l_P is essentially the radius of twistor sphere of M^4 so that in TGD the situation seemed to be settled since l_P would be purely geometric parameter rather than genuine coupling constant. But it is not! One should be able to understand why the ratio l_P/R but here quantum criticality, which should determine only the values of genuine coupling parameters, does not seem to help.

Remark: M^4 has twistor space as the usual conformal sense with metric determined only apart from a conformal factor and in geometric sense as $M^4 \times S^2$: these two twistor spaces are part of double fibering.

Could CP_2 radius R be the radius of M^4 twistor sphere, and could one say that Planck length l_P is actually equal to R : $l_P = R$? One might get $G = l_P^2/\hbar$ from $G = R^2/\hbar_{eff}$!

1. It is indeed important to notice that one has $G = l_P^2/\hbar$. \hbar is in TGD replaced with a spectrum of $\hbar_{eff} = n\hbar_0$, where $\hbar = 6\hbar_0$ is a good guess [L4, L15]. At flux tubes mediating gravitational interactions one has

$$\hbar_{eff} = \hbar_{gr} = \frac{GMm}{v_0} ,$$

where v_0 is a parameter with dimensions of velocity. I recently proposed a concrete physical interpretation for v_0 [L13] (see <http://tinyurl.com/yclfxb2>). The value $v_0 = 2^{-12}$ is suggestive on basis of the proposed applications but the parameter can in principle depend on the system considered.

2. Could one consider the possibility that twistor sphere radius for M^4 has CP_2 radius R : $l_P = R$ after all? This would allow to circumvent introduction of Planck length as new fundamental length and would mean a partial return to the original picture. One would $l_P = R$ and $G = R^2/\hbar_{eff}$. \hbar_{eff}/\hbar would be of $10^7 - 10^8$!

The problem is that \hbar_{eff} varies in large limits so that also G would vary. This does not seem to make sense at all. Or does it?!

To get some perspective, consider first the phase transition replacing \hbar and more generally $\hbar_{eff,i}$ with $\hbar_{eff,f} = \hbar_{gr}$.

1. Fine structure constant is what matters in electrodynamics. For a pair of interacting systems with charges Z_1 and Z_2 one has coupling strength $Z_1 Z_2 e^2 / 4\pi\hbar = Z_1 Z_2 \alpha$, $\alpha \simeq 1/137$.

- As shown in [K5, K4, K11, K10] one can also define gravitational fine structure constant α_{gr} . Only α_{gr} should matter in quantum gravitational scattering amplitudes. α_{gr} would be given by

$$\alpha_{gr} = \frac{GMm}{4\pi\hbar_{gr}} = \frac{v_0}{4\pi} . \tag{2.7}$$

$v_0/4\pi$ would appear as a small expansion parameter in the scattering amplitudes. This in fact suggests that v_0 is analogous to α and a universal coupling constant which could however be subject to discrete number theoretic coupling constant evolution.

- The proposed physical interpretation is that a phase transition $\hbar_{eff,i} \rightarrow \hbar_{eff,f} = \hbar_{gr}$ at the flux tubes mediating gravitational interaction between M and m occurs if the perturbation series in $\alpha_{gr} = GMm/4\pi/\hbar$ fails to converge ($Mm \sim m_{Pl}^2$ is the naive first guess for this value). Nature would be theoretician friendly and increase \hbar_{eff} and reducing α_{gr} so that perturbation series converges again.

Number theoretically this means the increase of algebraic complexity as the dimension $n = \hbar_{eff}/\hbar_0$ of the extension of rationals involved increases from n_i to n_f [L7] and the number n sheets in the covering defined by space-time surfaces increases correspondingly. Also the scale of the sheets would increase by the ratio n_f/n_i .

This phase transition can also occur for gauge interactions. For electromagnetism the criterion is that $Z_1 Z_2 \alpha$ is so large that perturbation theory fails. The replacement $\hbar \rightarrow Z_1 Z_2 e^2/v_0$ makes $v_0/4\pi$ the coupling constant strength. The phase transition could occur for atoms having $Z \geq 137$, which are indeed problematic for Dirac equation. For color interactions the criterion would mean that $v_0/4\pi$ becomes coupling strength of color interactions when α_s is above some critical value. Hadronization would naturally correspond to the emergence of this phase.

One can raise interesting questions. Is v_0 (presumably depending on the extension of rationals) a completely universal coupling strength characterizing any quantum critical system independent of the interaction making it critical? Can for instance gravitation and electromagnetism are mediated by the same flux tubes? I have assumed that this is not the case. It it could be the case, one could have for $GMm < m_{Pl}^2$ a situation in which effective coupling strength is of form $(GmMm/Z_1 Z_2 e^2)(v_0/4\pi)$.

The possibility of the proposed phase transition has rather dramatic implications for both quantum and classical gravitation.

- Consider first quantum gravitation. v_0 does not depend on the value of G at all! The dependence of G on \hbar_{eff} could be therefore allowed and one could have $l_P = R$. At quantum level scattering amplitudes would not depend on G but on v_0 . I was of course very happy after having found the small expansion parameter v_0 but did not realize the enormous importance of the independence on G ! Quantum gravitation would be like any gauge interaction with dimensionless coupling, which is even small! This might relate closely to the speculated TGD counterpart of AdS/CFT duality between gauge theories and gravitational theories.
- What about classical gravitation? Here G should appear. What could the proportionality of classical gravitational force on $1/\hbar_{eff}$ mean? The invariance of Newton's equation

$$\frac{d\bar{v}}{dt} = -\frac{GM\bar{r}}{r^3} \tag{2.8}$$

under $\hbar_{eff} \rightarrow x\hbar_{eff}$ would be achieved by scaling $\bar{r} \rightarrow \bar{r}/x$ and $t \rightarrow t/x$. Note that these transformations have general coordinate invariant meaning as scalings of Minkowski coordinates of M^4 in $M^4 \times CP_2$. This scaling means the zooming up of size of space-time sheet by x , which indeed is expected to happen in $\hbar_{eff} \rightarrow x\hbar_{eff}$!

What is so intriguing that this connects to an old problem that I pondered a lot during the period 1980-1990 as I attempted to construct the field equations for Kähler action approximate spherically symmetric stationary solutions [K6]. The naive arguments based on the asymptotic behavior of the solution ansatz suggested that the one should have $G = R^2/\hbar$. For a long time indeed assumed $R = l_P$ but p-adic mass calculations [K3] and work with cosmic strings [K1] forced to conclude that this cannot be the case. The mystery was how $G = R^2/\hbar$ could be normalized to $G = l_P^2/\hbar$: the solution of the mystery is $\hbar \rightarrow \hbar_{eff}$ as I have now - decades later - realized!

3 Is the hierarchy of Planck constants behind the reported variation of Newton's constant?

Nowadays it is fantastic to be a theoretical physicist with a predictive theory. Every week I get from FB links to fascinating experimental findings crying for explanation (I am grateful for people providing these links). The last link of this kind was to a popular article (see <http://tinyurl.com/ya2wekch>) telling about the article [E6] (see <http://tinyurl.com/yanvzxj6>) reporting measurements of Newton's constant G carried out by Chinese physicists Shan-Qing Yang, Cheng-Gang Shao, Jun Luo and colleagues at the Huazhong University of Science and Technology and other institutes in China and Russia. The outcomes of two experiments using different methods differ more than the uncertainties in the experiments, which forces to consider the possibility that G can vary.

In the sequel I consider a possible interpretation for the finding of a Chinese research group measuring two different values of G differing by 47 ppm in terms of varying \hbar_{eff} . Also a model for fountain effect of superfluidity as de-localization of wave function and increase of the maximal height of vertical orbit due to the change of the gravitational acceleration g at surface of Earth induced by a change of \hbar_{eff} due to super-fluidity is discussed. Also Podkletnov effect is considered. TGD inspired theory of consciousness allows to speculate about levitation experiences possibly induced by the modification of G_{eff} at the flux tubes for some part of the magnetic body accompanying biological body in TGD based quantum biology.

3.1 The experiments

The experiments use torsion pendulum: this method was introduced by Henry Cavendish in 1789.

Remark: A remark about terminology is in order. Torque $\tau = F \times r$ on particle has dimensions Nm. Torsion (see <http://tinyurl.com/q8esyumu>) in solid is essentially the density of torque per volume and has dimensions N/m². Twist angle is induced by torsion in equilibrium. The situation is governed by the theory of elasticity.

Basically one has torsion balance in which the gravitational torque produced by two source masses on masses associated with a torsion pendulum - dumbbell shaped system having identical masses at the ends of a bar and hanging from a thread at the middle point of the bar. As the source masses are rotated a twist of the thread emerges and twist angle corresponds to an equilibrium in which the torsion of the thread compensates the torque produced by gravitational interaction with source masses. Cavendish achieved 1 per cent accuracy in his measurements.

Refined variations of these measurements have been developed during years and the current precision is 47 parts per million (ppm). In some individual experiments the precision is 13.7 ppm. Disagreements larger than 500 ppm are reported, which suggests that new physics might be involved.

The latest experiments were made by the above mentioned research group. Two methods are used. TOS (Time Of Swing) and AAF (Angular Acceleration Feedback). AAF results deviates from the accepted value whereas TOS agrees. The accuracies were 11.64 ppm and 11.61 ppm in TOS and AAF respectively. AAF however gave by 45 ppm larger value of G .

In TOS technique the pendulum oscillates. The frequency of oscillation is determined by the positions of the external masses and G can be deduced by comparing frequencies for two different mass configurations. There are two equilibrium positions. The pendulum is either parallel to the line connecting masses relatively near to each other ("near" position). The pendulum orthogonal to the line connecting masses in "far" position. By measuring the different oscillation frequencies one can deduce the value of G .

Angular-acceleration feedback (AAF) method involves rotating the external masses and the pendulum on two separate turn tables. Twist angle is kept zero by changing the angular velocity of the other turn table: thus feedback is involved. If I have understood correctly, the torsion induced by gravitational torque compensates the torsion created by twisting of the thread around its axis in opposite direction and from the value of torsion for zero twist angle one deduces G . One could perhaps say that in AAF torsion is applied actively whereas in TOS it appears as reaction.

Why the measured value obtained for G would be larger for AAF? Could the active torsion inducing compensating twisting of the torsion pendulum actually increase G ?

3.2 TGD based explanation in terms of hierarchy of Newton's constants

Some time ago I added a piece to an article telling about change in my view about Planck length [L13] (see <http://tinyurl.com/yclfxb2>). In TGD hierarchy of Planck constants is predicted: $\hbar_{eff} = nh_0$ is integer multiple of $h_0 = h/6$. During writing this, it became clear that h_0 need not be minimal value h_{min} of \hbar_{eff} as I have assumed for some time (the first guess was that h is the minimal value).

This suggests also a hierarchy of Newton's constants $G_{eff} = l_P^2/\hbar_{eff}$ as subharmonics of l_P^2 , where Planck length l_P is now re-identified as $l_P = R$, where R is CP_2 "radius" which for $G_{eff} = G$ is about $10^{3.5}$ larger than ordinary Planck length $l_P = \sqrt{\hbar G}$. The corresponding value of \hbar_{eff} , call it $\hbar_{eff}(gr)$, would be $\hbar_{eff}(gr)/h_{min} \simeq 2^{24}$.

Remark: This raises a problem to be discussed in the application to fountain effect. $\hbar_{eff}(gr)$ is by factor of order 2^{24} larger than h , which looks strange since it involves delocalization of wave function to 2^{24} larger scale.

Could the variation of G - or better to call it G_{eff} - correspond to a variation of $\hbar_{eff}/h = n$ in G_{eff} ? Newton's constant for dark matter would be different from that for ordinary matter and vary in huge limits.

1. This looks non-sensical at first but would guarantee that one can scale up the solutions to Newton's equations by \hbar_{eff}/\hbar by scaling lengths by $n/n_0 = n/6$ [L4, L15, L22]: one would have thus scaling symmetry scaling also G_{eff} as is natural since it is dimensional parameter. Dark matter would be in rather precise sense zoomed up variants of ordinary matter and n would label the possible zoom ups.
2. \hbar_{eff} has spectrum and as a special case one has $\hbar_{eff} = \hbar_{gr} = GMm/v_0$. Is this case the gravitational coupling become $G_{eff}Mm = v_0$ and does not depend on masses or G at all. In quantum scattering amplitudes a dimensionless parameter $(1/4\pi)v_0/c$ would appear in the role of gravitational fine structure constant and would be obtained from $\hbar_{eff} = \hbar_{gr} = GMm/v_0$ consistent with Equivalence Principle. The miracle would be that G_{eff} would disappear totally from the perturbative expansion in terms of GMm as one finds by looking what $\alpha_{gr} = GMm/\hbar_{gr}$ is! This picture would work when GMm is larger than perturbative expansion fails to converge. For Mm above Planck mass squared this is expected to be the case. What happens below this limit is yet unclear (n is integer).

Could v_0 be fundamental coupling constant running only mildly? This does not seem to be the case: Nottale's original work proposing \hbar_{gr} proposes that v_0 for outer planets is by factor $1/5$ smaller than for the inner planets [K5, K11].

3. This picture works also for other interactions [?] Quite generally, nature would be theoretician friendly and induce a phase transition increasing \hbar when the coupling strength exceeds the value below which perturbation series converges so that perturbation series converges. In adelic physics this would mean increase of the algebraic complexity since $\hbar_{eff}/h = n$ is the dimension of extension of rationals inducing the extensions of various p-adic number fields and defining the particular level in the adelic hierarchy [L9, L10]. The parameters characterizing space-time surfaces as preferred extremals of the action principle would be numbers in this extension of rationals so that the phase transition would have a well-defined mathematical meaning. In TGD the extensions of rationals would label different quantum critical phases in which coupling constants would not run so that coupling constant evolution would be discrete as function of the extension.

4. This vision allows also to understand discrete coupling constant evolution replacing continuous coupling constant evolution of quantum field theories as being forced by the convergence of perturbation expansion and induced by the evolution defined by the hierarchy of extensions of rationals. When convergence is lost, a phase transition increasing algebraic complexity takes place and increases n . Extensions of rationals have also other characteristics than the dimension n .

For instance, each extension is characterized by ramified primes and the the proposal is that favoured p-adic primes assignable to cognition and also to elementary particles and physics in general correspond to so called ramified primes analogous to multiple zeros of polynomials. Therefore number theoretic evolution would also give rise to p-adic evolution as analog of ordinary coupling constant evolution with length scale.

At quantum criticality coupling constant evolution is trivial and in QFT context this would mean that loops vanish separately or at least they sum up to zero for the critical values of coupling constants. This argument however seems to make the whole argument about convergence of coupling constant expansion obsolete unless one allows only the quantum critical values of coupling constants guaranteeing that quantum TGD is quantum critical. There are strong reasons to believe that the TGD analog of twistor diagrammatics involves only tree diagrams and there are strong number theoretic argument for this: infinite sum of diagrams does not in general give a number in given extension of rationals. Quantum criticality would be forced by number theory.

5. This would solve a really big conceptual problem, which I did not realize as I discovered the twistor lift of TGD making the choice $M^4 \times CP_2$ unique [K14, K16] [L13]. The usual Planck length $l_P = \sqrt{\hbar G}$ as the radius of the M^4 twistor sphere would separate length scale from CP_2 scale R it is not a coupling constant like parameter and quantum criticality does not allow even in principle its understanding. The presence of two separate fundamental length scales in a theory intended to be unification does simply not make sense.

The variability of G with \hbar_{eff} could explain the variation of G in various experiments since for gravitational flux tubes $\hbar_{eff}/\hbar \sim 10^7$ would be true. The smallest variation would be of order 10^{-7} as n varies by one unit. This is a testable prediction (see <http://tinyurl.com/ycl1efxb2>).

As already explained, the maximum for the variation of G is 500 ppm = 5×10^{-4} . This would correspond to $\Delta n \sim 5 \times 10^3$. The difference between TOS and AAF is 47 ppm and would correspond to $\Delta n \sim 470$. The variation could be also due to a small variation, say $k \rightarrow k + 1$, for a prime factor k of n . 47 ppm would give $k \simeq 2,128$. For $k = 2^{11} \rightarrow k - 1$ in TOS to AAF and favored by number theoretic considerations would give $\Delta k/k = 49$ ppm.

Why small variations for the factors of n would be favored? If one assumes that number theoretical evolution corresponds to the increasing order of the Galois group such that the new Galois group contains the earlier Galois group as a subgroup (this would serve as an analogy for conserved genes in biological evolution). Larger Galois groups would naturally contain the "standard" Galois group associated with N as a sub-group. From number theoretic point of view the proposal $\hbar_{eff}/\hbar = N = 2^{24}$ is perhaps the simplest one since all Galois groups appearing as its sub-groups would have order with is 6×2^k for $h = 6h_0$. Larger values of \hbar_{eff}/\hbar should have N as a factor.

Why the presence of of the feedback torque on the torsion pendulum would reduce the value of $\hbar_{eff}/h = n$ by about 5×10^3 units in AAF for the gravitational flux tubes connecting the source masses to the masses of torsion pendulum from that in TOS? Somehow the value of \hbar_{eff} should be reduced.

3.3 A little digression: Galois groups and genes

As found, the question about possible variations of G_{eff} , leads to the idea that subgroups of Galois group could be analogous to conserved genes in that they could be conserved in number theoretic evolution. In small variations such as above variation Galois subgroups as genes would change only a little bit. For instance, the dimension of Galois subgroup would change.

The analogy between subgroups of Galois groups and genes goes also in other direction. I have proposed long time ago that genes (or maybe even DNA codons) could be labelled by $\hbar_{eff}/h = n$

. This would mean that genes (or even codons) are labelled by a Galois group of Galois extension (see <http://tinyurl.com/zu5ey96>) of rationals with dimension n defining the number of sheets of space-time surface as covering space. This could give a concrete dynamical and geometric meaning for the notion of gene and it might be possible some day to understand why given gene correlates with particular function. This is of course one of the big problems of biology.

One should have some kind of procedure giving rise to hierarchies of Galois groups assignable to genes. One would also like to assign to letter, codon and gene and extension of rationals and its Galois group. The natural starting point would be a sequence of so called intermediate Galois extensions E^H leading from rationals or some extension K of rationals to the final extension E . Galois extension has the property that if a polynomial with coefficients in K has single root in E , also other roots are in E meaning that the polynomial with coefficients K factorizes into a product of linear polynomials. For Galois extensions the defining polynomials are irreducible so that they do not reduce to a product of polynomials.

Any sub-group $H \subset Gal(E/K)$ leaves the intermediate extension E^H invariant in element-wise manner as a sub-field of E (see <http://tinyurl.com/y958drcy>). Any subgroup $H \subset Gal(E/K)$ defines an intermediate extension E^H and subgroup $H_1 \subset H_2 \subset \dots$ define a hierarchy of extensions $E^{H_1} \supset E^{H_2} \supset E^{H_3} \dots$ with decreasing dimension. The subgroups H are normal - in other words $Gal(E)$ leaves them invariant and $Gal(E)/H$ is group. The order $|H|$ is the dimension of E as an extension of E^H . This is a highly non-trivial piece of information. The dimension of E factorizes to a product $\prod_i |H_i|$ of dimensions for a sequence of groups H_i .

Could a sequence of DNA letters/codons somehow define a sequence of extensions? Could one assign to a given letter/codon a definite group H_i so that a sequence of letters/codons would correspond a product of some kind for these groups or should one be satisfied only with the assignment of a standard kind of extension to a letter/codon?

Irreducible polynomials define Galois extensions and one should understand what happens to an irreducible polynomial of an extension E^H in a further extension to E . The degree of E^H increases by a factor, which is dimension of E/E^H and also the dimension of H . Is there a standard manner to construct irreducible extensions of this kind?

1. What comes into mathematically uneducated mind of physicist is the functional decomposition $P^{m+n}(x) = P^m(P^n(x))$ of polynomials assignable to sub-units (letters/codons/genes) with coefficients in K for a algebraic counterpart for the product of sub-units. $P^m(P^n(x))$ would be a polynomial of degree $n + m$ in K and polynomial of degree m in E^H and one could assign to a given gene a fixed polynomial obtained as an iterated function composition.

Intuitively it seems clear that in the generic case $P^m(P^n(x))$ does not decompose to a product of lower order polynomials. One must be however cautious here. It can be shown (see <https://arxiv.org/pdf/1511.06446.pdf>) that the probability that a random polynomial with rational coefficients is irreducible behaves as $O(\log N/N)$, where N is upper bound for the magnitude of coefficients. On the other hand, the probability that a random monic polynomial (integer coefficients and unit constant coefficient) is not irreducible (factorizes) goes as $O(1/N)$. It is also shown that by their special properties permutation groups S_n are strongly favoured as Galois groups.

One could use also polynomials assignable to codons or letters as basic units. Also polynomials of genes could be fused in the same manner.

The choice of polynomials P^n is rather free since for given order of Galois group there are only finite number of finite groups and the number of polynomials is infinite. The first cautious guess is that the Galois group depends rather weakly on the rational coefficients regarded as real numbers.

2. If the iteration of polynomial maps indeed gives a Galois extensions, the dimension m of the intermediate extension should be same as the order of its Galois group. Composition would be non-commutative but associative as the physical picture demands. The longer the gene, the higher the algebraic complexity would be. Could functional decomposition define the rule for who extensions and Galois groups correspond to genes? Very naively, functional decomposition in mathematical sense would correspond to composition of functions in biological sense.

3. This picture would conform with $M^8 - M^4 \times CP_2$ correspondence [L7] in which the construction of space-time surface at level of M^8 reduces to the construction of zero loci of polynomials of octonions, with rational coefficients. DNA letters, codons, and genes would correspond to polynomials of this kind.

Could one say anything about the Galois groups of DNA letters?

1. Since $n = h_{eff}/h$ serves as a kind of quantum IQ, and since molecular structures consisting of large number of particles are very complex, one could argue that n for DNA or its dark variant realized as dark proton sequences can be rather large and depend on the evolutionary level of organism and even the type of cell (neuron viz. soma cell). On the other, hand one could argue that in some sense DNA, which is often thought as information processor, could be analogous to an integrable quantum field theory and be solvable in some sense. Notice also that one can start from a background defined by given extension K of rationals and consider polynomials with coefficients in K . Under some conditions situation could be like that for rationals.
2. The simplest guess would be that the 4 DNA letters correspond to 4 non-trivial finite groups with smaller possible orders: the cyclic groups Z_2, Z_3 with orders 2 and 3 plus 2 finite groups of order 4 (see the table of finite groups in <http://tinyurl.com/j8d5uyh>). The groups of order 4 are cyclic group $Z_4 = Z_2 \times Z_2$ and Klein group $Z_2 \oplus Z_2$ acting as a symmetry group of rectangle that is not square - its elements have square equal to unit element. All these 4 groups are Abelian. Polynomial equations of degree not larger than 4 can be solved exactly in the sense that one can write their roots in terms of radicals.
3. Could there exist some kind of connection between the number 4 of DNA letters and 4 polynomials of degree less than 5 for whose roots one can write closed expressions in terms of radicals as Galois found? Could it be that the polynomials obtained by a repeated functional composition of the polynomials of DNA letters have also this solvability property?

This could be the case! Galois theory states that the roots of polynomial are solvable by radicals if and only if the Galois group is solvable meaning that it can be constructed from abelian groups using Abelian extensions (see <http://tinyurl.com/ybcua92y>).

Solvability translates to a statement that the group allows so called sub-normal series $1 < G_0 < G_1 \dots < G_k$ such that G_{j-1} is normal subgroup of G_j and G_j/G_{j-1} is an abelian group. An equivalent condition is that the derived series $G \triangleright G^{(1)} \triangleright G^{(2)} \triangleright \dots$ in which $j+1$:th group is commutator group of G_j ends to trivial group. If one constructs the iterated polynomials by using only the 4 polynomials with Abelian Galois groups, the intuition of physicist suggests that the solvability condition is guaranteed!

4. Wikipedia article also informs that for finite groups solvable group is a group whose composition series has only factors which are cyclic groups of prime order. Abelian groups are trivially solvable, nilpotent groups are solvable, p-groups (having order, which is power prime) are solvable and all finite p-groups are nilpotent.

Every group with order less than 60 elements is solvable. Fourth order polynomials can have at most S_4 with 24 elements as Galois groups and are thus solvable. Fifth order polynomials can have the smallest non-solvable group, which is alternating group A_5 with 60 elements as Galois group and in this case are not solvable. S_n is not solvable for $n > 4$ and by the finding that S_n as Galois group is favored by its special properties (see <http://tinyurl.com/y6wyq9v2>).

A_5 acts as the group icosahedral orientation preserving isometries (rotations). Icosahedron and tetrahedron glued to it along one triangular face play a key role in TGD inspired model of bio-harmony and of genetic code [L1, L23]. The gluing of tetrahedron increases the number of codons from 60 to 64. The gluing of tetrahedron to icosahedron also reduces the order of isometry group to the rotations leaving the common face fixed and makes it solvable: could this explain why the ugly looking gluing of tetrahedron to icosahedron is needed? Could the smallest solvable groups and smallest non-solvable group be crucial for understanding the number theory of the genetic code.

An interesting question inspired by M^8-H -duality [L7] is whether the solvability could be posed on octonionic polynomials as a condition guaranteeing that TGD is integrable theory in number theoretical sense or perhaps following from the conditions posed on the octonionic polynomials. Space-time surfaces in M^8 would correspond to zero loci of real/imaginary parts (in quaternionic sense) for octonionic polynomials obtained from rational polynomials by analytic continuation. Could solvability relate to the condition guaranteeing M^8 duality boiling down to the condition that the tangent spaces of space-time surface are labelled by points of CP_2 . This requires that tangent or normal space is associative (quaternionic) and that it contains fixed complex sub-space of octonions or perhaps more generally, there exists an integrable distribution of complex subspaces of octonions defining an analog of string world sheet.

3.4 Does fountain effect involve non-standard value of G ?

Deviations in the value of G are not new, and I have written about several gravitational anomalies. This could mean also anti-gravity effects in a well-defined sense which is however not the same as often thought (negative gravitational masses or repulsive gravitational force).

In particular, there is well-known fountain effect (<http://tinyurl.com/kx3t52r>) in superfluidity in which superfluid seems to defy gravitation. I have proposed that $h_{eff}/h = n$ increases at superfluid flux tubes to h_{gr} and this gives to the effect as a de-localization in much longer scale [K10]. If also G is reduced so that the effect would be possible also classically? Since in superfluidity one has h_{eff} larger than usually, this might happen if gravitons travel also along flux tubes at which super fluid flows. This would change the earlier quantum estimates: in Schrödinger equation kinetic term scales up like $(h_{eff}/h)^2$ as before but gravitational potential of Earth would now scaled down like h/h_{eff} .

A simple model for the situation discussed in [K10] would rely on Schrödinger equation at the flux quantum which is locally a thin hollow cylinder turning around at the top of the wall of the container. In the following a slightly modified discussing replacing the gravitational acceleration g at surface of Earth with g_{eff}

1. One obtains 1-dimensional Schrödinger equation

$$\left(-\frac{\hbar_{eff}^2 \partial_z^2}{2m} + mg_{eff}z\right)\Psi = E\Psi \quad , \quad h_{eff} = nh_0 = \frac{n\hbar}{6} \quad . \quad (3.1)$$

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

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

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

2. One can introduce the dimensionless variable

$$u = \frac{z - \frac{E}{mg_{eff}}}{z_0} \quad , \quad z_0 = \left[\frac{2m^2 g_{eff}}{\hbar_{eff}^2}\right]^{-1/3} = \frac{n}{6} \left(\frac{h_{eff}(gr)}{h_{eff}}\right)^{1/3} \left(\frac{m}{m_p}\right)^{1/3} x \times \frac{\hbar c}{m_p} \quad , \quad (3.2)$$

$$\frac{\hbar c}{m_p} = \frac{L_p}{2\pi} \simeq .38 \times 10^{-12} \text{ m} \quad , \quad x = \left(\frac{m_p c^3}{\hbar g}\right)^{1/3} \simeq 1.5 \times 10^{10} \quad .$$

Here m_p denotes proton mass and L_p proton Compton length. z_0 scales as \hbar_{eff} as one might expect. z_0 characterizes roughly the scale of the solution.

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

$$-\frac{d^2\Psi}{du^2} + u\Psi = 0 . \quad (3.3)$$

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

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

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

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

$$z_0 = z_{cl} + u_0 z_0 , \quad z_{cl} = \frac{E}{mg_{eff}} , \quad z_0 = \frac{h_{eff}}{h} \left[\frac{\hbar^2}{2m^2g} \right]^{1/3} . \quad (3.4)$$

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

This picture however leads to an objection.

1. If one has $\hbar_{eff}(gr)/\hbar \simeq 2^{24}$ at the flux tubes mediating gravitational interaction for the ordinary value of g (the estimates for $R^2\hbar/G$ are within range $10^6 - 10^7$), one can argue that one must use this value of \hbar in the Schrödinger equation for a particle in the gravitational field of Earth. One would have $z_0 \simeq 2^{-8} \times 250$ m. This is much larger than the value $z_0 \simeq 5.7$ mm for \hbar and the high value might be excluded already by the existing data for neutron's behavior in Earth's gravitational field. This value is also higher than the de-localization scale of order 1 meter in fountain effect.
2. If one assumes $h_{eff} = h$ and scaled up value of g corresponding to $G_{eff} = R^2/\hbar$, one obtains scaling of z_0 by $(h/\hbar_{eff}(gr))^{1/3} \simeq 2^{-8}$ giving $z_0 \simeq .2$ mm from the previous equation - note however the dependence on E . This could correspond to the ordinary situation. At electromagnetic flux tubes h_{eff} would be smaller and also G_{eff} considerably smaller as the radially symmetric stationary extremals studied during eighties indeed suggested. The increased gravitation would be masked by much stronger electromagnetic interaction so that the testing of this prediction is difficult. At gravitational flux tubes one would have a spectrum of values and h_{gr} might represent the upper bound at quantum criticality for which the dependence of scattering amplitudes on masses disappears. $\hbar_{eff}(gr)$ would correspond to the measured value of $G_{eff} = G$.

Remark: One can of course ask whether $h_0 = h/6$ indeed represents the minimal value of h_{eff} . In principle one can also consider smaller values \hbar/k and this would give rise to $G_{eff} = kR^2$ with a shorter de-localization scale.

Can one say something about the spectrum of h_{eff} ? If one assumes that number theoretical evolution corresponds to the increasing order of the Galois group such that the new Galois group contains earlier Galois group as subgroup (this would serve as an analogy for conserved genes in biological evolution). Larger Galois groups would naturally contain the “standard” Galois group associated with N as a sub-group. From number theoretic point of view the proposal $\hbar_{eff}/\hbar = N = 2^{24}$ is perhaps the simplest one since all Galois groups appearing as its subgroups would have order with is 6×2^k for $h = 6h_0$. h_{eff}/\hbar should have N as a factor.

It seems that one must assume accept G_{eff} is indeed different for different flux tubes.

1. For proton mass $m = m_p$, $h_{eff} = h$, and $g_{eff} = 2^{24}g$ one would have $z_0 \simeq .2$ mm as one finds from the previous equation. $h_{eff}/h_{eff}(gr) = 2^{12}$ would give $z_0 \simeq 89.1$ cm, which makes sense for fountain effect. The value $h_{eff}/h = 2^{36}$ looks quite conceivable at flux tubes mediating electromagnetic interaction and carrying suprafluid flow. I have considered years ago the hypothesis that h_{eff}/h could come as powers of 2^{11} . Note that the estimate $v_0 \simeq 2^{-11}$ is also power of 2 so that powers of 2 are suggestive.
2. $\hbar_{eff} = \hbar_{gr} = GM_D m/v_0$ corresponds to a large value of h_{eff} and might be assignable to flux tubes mediating dark part of gravitational interaction

$$z_0 = \frac{c}{v_0} \frac{r_S}{2} \frac{M_D}{M_E} \left(\frac{m}{m_p}\right)^{1/3}, \quad x = \left(\frac{m_p c^3}{\hbar g}\right)^{1/3} \simeq 1.5 \times 10^{10}, \quad r_S = 2GM_E \simeq 9 \text{ mm} .$$

More concretely:

$$z_0 \simeq \frac{M_D}{M_E} \times 6 \times 10^7 \text{ km} .$$

The estimate for M_D/M_E is $M_D/M_E \sim 10^{-4}$. An open question is whether M_D should be interpreted as dark mass or whether one should interpret M_D/M_E as a mere parameterization for $\hbar_{eff} = (n/6)\hbar$ as $\hbar_{eff} = (M_D/M_E)\hbar_{gr}$. z_0 characterizes the de-localization scale for the solutions. It is clear that this scale is many orders of magnitudes larger than the de-localization scale about 1 m for superfluids.

3.5 Does Podkletnov effect involve non-standard value of G ?

Podkletnov observed [H1] at eighties a few percent reduction of gravity: he immediately lost his job in Tampere University in Finland. It was regarded as a scandalous event. Something new might have been discovered in finnish laboratory!

I have considered a possible mechanism explaining the finding of Podkletnov [L2]. One could however ask whether the presence of superconductor involving also presence of phase with non-standard value of Planck constant could also affect the value of h_{eff} assignable to the flux tubes of the Kähler magnetic field mediating Earth’s gravitational flux? The mechanism would be same as in fountain effect. The change $\Delta g_{eff}/g$ from the normal value would have been few per cent in this case.

3.6 Did LIGO observe non-standard value of G and are galactic black-holes really supermassive?

Also smaller values of G than the G_N are possible and in fact, in condensed matter scales it is quite possible that $n = R^2/G$ is rather small. Gravitation would be stronger but very difficult to detect in these scales. Neutron in the gravitational field of Earth might provide a possible test. The general rule would be that the smaller the scale of dark matter dynamics, the larger the value of G and maximum value would be $G_{max} = R^2/h_0$, $h = 6h_0$.

3.6.1 Are the blackholes detected by LIGO really so massive?

LIGO (see <http://tinyurl.com/bszfs29>) has hitherto observed 3 fusions of black holes giving rise to gravitational waves. For TGD view about the findings of LIGO see [L5, L3] (see <http://tinyurl.com/y79yqw6q> and <http://tinyurl.com/ya8ctxgc>). The colliding blackholes were deduced to have unexpectedly larger large masses: something like 10-40 solar masses, which is regarded as something rather strange.

Could it be that the masses were actually of the order of solar mass and G was actually larger by this factor and h_{eff} smaller by this factor? The mass of the colliding blackholes could be of order solar mass and G would larger than its normal value - say by a factor in the range (10,50). If so, LIGO observations would represent the first evidence for TGD view about quantum gravitation, which is very different from superstring based view. The fourth fusion was for neutron stars rather than black holes and stars had mass of order solar mass.

This idea works if the physics of gravitating system depends only on $G(M+m)$. That classical dynamics depends on $G(M+m)$ only, follows from Equivalence Principle. But is this true also for gravitational radiation? If the power of gravitational radiation distinguishes between different values of M when GM is kept constant, the idea is dead.

1. If the power of gravitational radiation distinguishes between different values of $M+m$, when $G(M+m)$ is kept constant, the idea is dead. This seems to be the case. The dependence on $G(M+m)$ only leads to contradiction at the limit when $M+m$ approaches zero and $G(M+m)$ is fixed. The reason is that the energy emitted per single period of rotation would be larger than $M+m$. The natural expectation is that the radiated power per cycle and per mass $M+m$ depends on $G(M+m)$ only as a dimensionless quantity.
2. From arXiv one can find an article (see <http://tinyurl.com/y99j3fpr>) in which the energy per unit solid angled and frequency radiated in collision of blackholes is estimated. The outcome is proportional to $E^2 G(M+m)^2$, where E is the energy of the colliding blackhole. The result is proportional mass squared measured in units of Planck mass squared as one might indeed naively expect since $G(M+m)^2$ is analogous to the total gravitational charge squared measured using Planck mass. The proportionality to E^2 comes from the condition that dimensions come out correctly. Therefore the scaling of G upwards would reduce mass and the power of gravitational radiation would be reduced down like $M+m$. The power per unit mass depends on $G(M+m)$ only. Gravitational radiation allows to distinguish between two systems with the same Schwarzschild radius, although the classical dynamics does not allow this.
3. One can express the classical gravitational energy E as gravitational potential energy proportional to GM/R . This gives only dependence on GM as also Equivalence Principle for classical dynamics requires and for the collisions of blackholes R is measured by using $G(M+m)$ as a natural unit.

Remark: The calculation uses the notion of energym which in general relativity is precisely defined only for stationary solutions. Radiation spoils the stationarity. The calculations of the radiation power in GRT is to some degree artwork feeding in the classical conservation laws in post-Newtonian approximation lost in GRT. In TGD framework the conservation laws are not lost and hold true at the level of $M^4 \times CP_2$.

3.6.2 What about supermassive galactic blackholes?

What about supermassive galactic black holes in the centers of galaxies: are they really super-massive or is G super-large! The mass of Milky Way super-massive blackhole is in the range $10^5 - 10^9$ solar masses. Geometric mean is $n = 10^7$ solar masses and of the order of the standard value of $R^2/G_N = n \sim 10^7$. Could one think that this blackhole has actually mass in the range 1-100 solar masses and assignable to an intersection of galactic cosmic string with itself! How galactic blackholes are formed is not well understood. Now this problem would disappear. Galactic blackholes would be there from the beginning!

The general conclusion is that only gravitational radiation allows to distinguish between different masses $M + m$ for given $G(M + m)$ in a system consisting of two masses so that classically scaling the opposite scalings of G and $M + m$ is a symmetry.

3.7 Is it possible to determine experimentally whether gravitation is quantal interaction?

Marletto and Vedral have proposed an interesting method for measuring whether gravitation is quantal interaction (see <https://arxiv.org/pdf/1707.06036.pdf>).

I tried to understand what the proposal suggests and how it translates to TGD language.

1. If gravitational field is quantum it makes possible entanglement between two states. This is the intuitive idea but what it means in TGD picture? Feynman interpreted this as entanglement of gravitational field of an objects with the state of object. If object is in a state, which is superposition of states localized at two different points x_i , the classical gravitational fields ϕ_{gr} are different and one has a superposition of states with different locations

$$|I\rangle = \sum_{i=1,2} |m_i \text{ at } x_i\rangle |\phi_{gr,x_i}\rangle \equiv |L\rangle + |R\rangle .$$

2. Put two such de-localized states with masses m_i at some distance d to get state $|1\rangle|2\rangle$, $|i\rangle = |L\rangle_i + |R\rangle_i$. The 4 components pairs of the states interact gravitationally and since there are different gravitational fields between different states the states get different phases, one can obtain entangled state.

Gravitational field would entangle the masses. If one integrates over the degrees of freedom associated with gravitational field one obtains density matrix and the density matrix is not pure if gravitational field is quantum in the sense that it entangles with the particle position.

That gravitation is able to entangle the masses would be a proof for the quantum nature of gravitational field. It is not however easy to detect this. If gravitation only serves as a parameter in the interaction Hamiltonian of the two masses, entanglement can be generated but does not prove that gravitational interaction is quantal. It is required that the only interaction between the systems is gravitational so that other interactions do not generate entanglement. Certainly, one should use masses having no em charges.

3. In TGD framework the view of Feynman is natural. One has superposition of space-time surfaces representing this situation. Gravitational field of particle is associated with the magnetic body of particle represented as 4-surface and superposition corresponds to a de-localized quantum state in the "world of classical worlds" with x_i representing particular WCW coordinates.

I am not specialist in quantum information theory nor as quantum gravity experimentalist, and hereafter I must proceed keeping fingers crossed and I can only hope that I have understood correctly. To my best understanding, the general idea of the experiment would be to use interferometer to detect phase differences generated by gravitational interaction and inducing the entanglement. Not for photons but for gravitationally interacting masses m_1 and m_2 assumed to be in quantum coherent state and be describable by wave function analogous to em field. It is assumed that gravitational interact can be describe classically and this is also the case in TGD by quantum-classical correspondence.

1. Authors think quantum information theoretically and reduce everything to qubits. The de-localization of masses to a superposition of two positions correspond to a qubit analogous to spin or a polarization of photon.
2. One must use and analog of interferometer to measure the phase difference between different values of this "polarization".

In the normal interferometer is a flattened square like arrangement. Photons in superpositions of different spin states enter a beam splitter at the left-lower corner of interferometer dividing

the beam to two beams with different polarizations: horizontal (H) and vertical (V). Vertical (horizontal) beam enters to a mirror which reflects it to horizontal (vertical beam). One obtains paths V-H and H-V meeting at a transparent mirror located at the upper right corner of interferometer and interfere.

There is detector D_0 resp. D_1 detecting component of light gone through in vertical resp. horizontal direction of the fourth mirror. Firing of D_1 would select the H-V and the firing of D_0 the V-H path. This thus would tell what path (V-H or H-V) the photon arrived. The interference and thus also the detection probabilities depend on the phases of beams generated during the travel: this is important.

3. If I have understood correctly, this picture about interferometer must be generalized. Photon is replaced by mass m in quantum state which is superposition of two states with polarizations corresponding to the two different positions. Beam splitting would mean that the components of state of mass m localized at positions x_1 and x_2 travel along different routes. The wave functions must be reflected in the first mirrors at both path and transmitted through the mirror at the upper right corner. The detectors D_i measure which path the mass state arrived and localize the mass state at either position. The probabilities for the positions depend on the phase difference generated during the path. I can only hope that I have understood correctly: in any case the notion of mirror and transparent mirror in principle make sense also for solutions of Schrödinger equation.
4. One must however have two interferometers. One for each mass. Masses m_1 and m_2 interact quantum gravitationally and the phases generated for different polarization states differ. The phase is generated by the gravitational interaction. Authors estimate that phases generated along the paths are of form

$$\Phi_i = \frac{m_1 m_2 G}{\hbar d_i} \Delta t .$$

$\Delta t = L/v$ is the time taken to pass through the path of length L with velocity v . d_1 is the smaller distance between upper path for lower mass m_2 and lower path for upper mass m_1 . d_2 is the distance between upper path for upper mass m_1 and lower m_2 . See Figure 1 of the article (see <https://arxiv.org/pdf/1707.06036.pdf>).

What one needs for the experiment?

1. One should have de-localization of massive objects. In atomic scales this is possible. If one has $h_{eff}/h_0 > h$ one could also have zoomed up scale of de-localization and this might be very relevant. Fountain effect of superfluidity pops up in mind.
2. The gravitational fields created by atomic objects are extremely weak and this is an obvious problem. Gm_1m_2 for atomic mass scales is extremely small: since Planck mass m_P is something like 10^{19} proton masses and atomic masses are of order 10-100 atomic masses.

One should have objects with masses not far from Planck mass to make Gm_1m_2 large enough. Authors suggest using condensed matter objects having masses of order $m \sim 10^{-12}$ kg, which is about 10^{15} proton masses 10^{-4} Planck masses. Authors claim that recent technology allows de-localization of masses of this scale at two points. The distance d between the objects would be of order micron.

3. For masses larger than Planck mass one could have difficulties since quantum gravitational perturbation series need not converge for $Gm_1m_2 > 1$ (say). For proposed mass scales this would not be a problem.

What can one say about the situation in TGD framework?

1. In TGD framework the gravitational Planck $h_{gr} = Gm_1m_2/v_0$ assignable to the flux tubes mediating interaction between m_1 and m_2 as macroscopic quantum systems could enter into the game and could reduce in extreme case the value of gravitational fine structure constant from $Gm_1m_2/4\pi\hbar$ to $Gm_1m_2/4\pi\hbar_{eff} = \beta_0/4\pi$, $\beta_0 = v_0/c < 1$. This would make

perturbation series convergent even for macroscopic masses behaving like quantal objects. The physically motivated proposal is $\beta_0 \sim 2^{-11}$. This would zoom up the quantum coherence length scales by h_{gr}/\hbar .

2. What can one say in TGD framework about the values of phases Φ ?

(a) For $\hbar \rightarrow \hbar_{eff}$ one would have

$$\Phi_i = \frac{Gm_1m_2}{\hbar_{eff}d_i} \Delta t .$$

For $\hbar \rightarrow \hbar_{eff}$ the phase differences would be reduced for given Δt . On the other hand, quantum gravitational coherence time is expected to increase like \hbar_{eff} so that the values of phase differences would not change if Δt is increased correspondingly. The time of 10^{-6} seconds could be scaled up but this would require the increase of the total length L of interferometer arms and/or slowing down of the velocity v .

(b) For $\hbar_{eff} = \hbar_{gr}$ this would give a universal prediction having no dependence on G or masses m_i

$$\Phi_i = \frac{v_0 \Delta t}{d_i} = \frac{v_0}{v} \frac{L}{d_i} .$$

If Planck length is actually equal to CP_2 length $R \sim 10^{3.5} \sqrt{G_N \hbar}$, one would have $G_N = R^2/\hbar_{eff}$, $\hbar_{eff} \sim 10^7$. One can consider both smaller and larger values of G and for larger values the phase difference would be larger. For this option one would obtain $1/\hbar_{eff}^2$ scaling for Φ . Also for this option the prediction for the phase difference is universal for $\hbar_{eff} = \hbar_{gr}$.

(c) What is important is that the universality could be tested by varying the masses m_i . This would however require that m_i behave as coherent quantum systems gravitationally. It is however possible that the largest quantum systems behaving quantum coherently correspond to much smaller masses.

3.8 Conscious experiences about antigravity

Conscious experiences about anti-gravitational effects have been also reported and since I have nothing to lose as a happy pensioner and consciousness theorist [L11] I can take the liberty to talk also about these effects, even at personal level.

1. There are stories about flying yoga masters. I am skeptic but I know from my own experience that out-of-body and levitation experiences - I mean indeed *experiences* - feel very real. I have proposed a model explaining them based on the notion of magnetic body as intentional agent carrying dark matter and using biological body as sensory receptor and motor instrument.
2. I have indeed spent at younger age many moments in a kind of between away-and-sleep state in the roof of bedroom trying to prove myself that I really am there and then suddenly returned back to normal in wake-up state. Even the matresse behaved how it is expected to behave as some-one falls on it. Maybe part of my magnetic body was out-of-biological body after having experienced $\hbar_{eff}/\hbar = n$ increasing phase transition! Sometimes I have experienced wakeup quite concretely as a kind of contraction in which I have returned to my body: reduction of $\hbar_{eff}/\hbar = n$ for some part of magnetic body would explain this.
3. I have had also altered states of consciousness between wake-up and sleep in which I felt my body like oscillating and being attracted by refrigerator, whose sound had started to amplify. I experienced the refrigerator as a living being and I was afraid that it intended engulf my consciousness! I had to decide whether I let it go but did not have courage to do it and I returned to the normal state.

4. In dreams I have been also routinely flying and with somewhat childish narcissism pretended to the other people in dream that this is perfectly normal for me, it just occurred me that it would be fun to fly but honestly: I did not realize that it might make you scared! What was remarkable that I never got above about 10 meters: could this correspond to jumping in air in a reduced gravitational field? As a matter of fact, in dream I was typically going down in stairs and then decided to fly. I often landed at the end of stairs. This would fit with reduced gravity implying weaker downwards gravitational acceleration.

4 TGD inspired solution to two cosmological anomalies

I learned within a period of week about two cosmological anomalies new to me. The first anomaly is 160 minute oscillations discovered by Kotov and associated with a wide range of astrophysical systems. Second anomaly is the ionization of the interstellar gas. There might be a connection between these anomalies.

4.1 Could 160 minute oscillation affecting Galaxies and the Solar System correspond to cosmic “alpha rhythm”?

Kotov has discovered that many celestial objects involve 160 minute oscillation, whose origin is not identified. There is an overwhelming evidence that a non-local phenomenon is in question. TGD suggests an explanation as a kind of cosmic alpha rhythm. Fe^{2+} has 10 Hz alpha frequency, which is fundamental biorhythm as cyclotron frequency in .2 Gauss magnetic field assigned as endogenous magnetic field to living matter in TGD based quantum model of living matter. In .2 nT magnetic field which is consistent with empirically estimated values of interstellar magnetic field the cyclotron period is 160 minutes.

This co-incidence suggests that dark cyclotron photons with large value of Planck constant $h_{eff} = nh_0$ assigned with the phases of ordinary matter identifiable as dark matter and residing at magnetic flux tubes - in particular those carrying dark gravitons - induces the oscillations. The quantum coherence of dark matter would induce the coherence of oscillations in astrophysical length scales. The quantum effects on visible matter could be non-trivial since the energy $E = h_{eff}f$ of dark photons can be above thermal threshold. The same mechanism is central in TGD based quantum model for the control of visible bio-matter by dark matter.

4.1.1 Observations

The blog posting in Tallbloke’s talkshop titled “*Evidence for a 160 minute oscillation affecting Galaxies and the Solar System*” [E3] (see <http://tinyurl.com/y5en9cxz>) tells about the finding by Valery Kotov that many celestial objects have parameters, which correspond to a fundamental frequency of 160.0101 minutes. There is an overwhelming evidence that a non-local phenomenon is in question. For instance, Earth day is 9 times 160 minutes.

The blog articles [E3, E4] give a long list of links to the works demonstrating the presence of this period: see for instance [E1, E2].

160 minute period occurs in many contexts.

1. Infrasonic oscillations, measured by Doppler effect, on the surface of Sun corresponds to a period of 160,01 minutes. These oscillations were discovered by Severny, Kotov, and Tsapp [E1, E2] and independently by Brookes et al. They were later conformed by two other teams - for references see the article “*Solar Activity, Wave of Kotov and Strange Coincidences*” [E4] (see <http://tinyurl.com/y6bfzy4q>). The following properties of Kotov waves are listed.
 - (a) These waves are perfectly periodic and regular: no break of phase was observed over more than thirty years of observations
 - (b) There are periods when the oscillation becomes blurred for the benefit of it’s lobe in 159.956 minutes (modulation in 400 days).
 - (c) The mode of vibration is badly identified.

- (d) The mechanism is not understood. V. Kotov proposes the influence of gravitational waves to explain the phenomenon but this explanation seems unrealistic.
2. The 160.0102 ± 0.0002 minutes appears also in solar eruptions.
3. There is a variation of the luminosity of Sun with period about 160/and or 80 minutes of Sun
4. The period of variations of luminosity of Delta Scuti stars has been found to be 162 ± 4 min and RR Lyrae stars 161.4 ± 1.6 minutes.
5. Kotov waves have been reported to occur even in quasars such as NGC 4151 and 3C 273 (see <http://tinyurl.com/yxcwh4r1>).

4.1.2 A possible TGD based explanation of Kotov waves

This finding relates in an interesting manner to the TGD based model of living systems in which cyclotron frequencies in endogenous magnetic field of $B_{end} = .2$ Gauss = $.2 \times 10^{-4}$ Tesla play a key role. The nominal value for the strength of the magnetic field of Earth varies since the value of B_E depends on position on surface of Earth. I have taken it as $B_E = .5$ Gauss but also $B_E = .3$ Gauss is mentioned. Whether $B_{end} = B_E$ can be assumed, is not clear.

1. For iron the cyclotron frequency of Fe^{2+} ion playing crucial role in oxygen based life is around 10 Hz, which serves as a fundamental biorhythm - alpha rhythm.
2. 160 min cyclotron frequency for Fe would correspond to magnetic field of .2 nT.
3. Interstellar or galactic magnetic field strengths are not far from this strength.
 - 1 nT for galactic magnetic field is claimed (see <http://tinyurl.com/yzesn4k>). This would give 32 min period.
 - For interstellar magnetic field the value 0.1 nTesla for interstellar magnetic field is claimed (see <http://tinyurl.com/y45hq72k>). Also the value .3 nT is claimed (see <http://tinyurl.com/glj8gvu>).

The proposed value .2 nT is half-way between these two values. Maybe there is fundamental biorhythm in cosmic scales! This is more or less predicted by TGD based vision about quantum coherence in all length scales made possible by the hierarchy $h_{eff} = n \times h_0$ of Planck constants predicted to define phases of ordinary matter identifiable as dark matter.

1. For large values of h_{eff} predicted by TGD the energies of the dark cyclotron photons can be above thermal threshold in living matter. This implies that the dark cyclotron radiation can have non-trivial effects on living manner: this kind of effects actually led to the idea about hierarchy of Planck constants. Now it can be deduced from what I call adelic physics [L9] (see <http://tinyurl.com/ycbhse5c>). The proposal is that bio-photons covering at least visible and UV range - the range of molecular transition energies - result as dark photons with say EEG frequencies transform to ordinary photons [K9].
2. In TGD inspired biology the cyclotron frequencies define coordinating rhythms [K8, K7] and the recent proposal [L21] (see <http://tinyurl.com/y4vtcv8u>) is that both sensory perception and motor actions and long term memory rely on a universal mechanism based on formation of holograms and their reading using dark cyclotron photon beam as reference beam. Could this mean that this mechanism is used even in galactic and cosmic scales so that life would be everywhere as TGD based theory of consciousness predicts?
3. If quantum coherence in astrophysical scales is involved, the values of h_{eff} would be very large and given by the Nottale formula $h_{eff} = h_{gr} 0GMm/v_0$, where $v_0 < c$ is velocity parameter and M and m are the masses connected by the magnetic flux tubes carrying gravitons [L12]. The dark photons involved would have large energies $E = h_{eff} f$ and could therefore energies in the range of molecular transition energies and have effects on the dynamics of astrophysical system just as they would have on the physiology of brain behavior [?].

- Note that the magnetic flux tubes as parts of topologically highly non-trivial space-time surface would have sphere rather than disk as cross section. Although the value of Kähler magnetic and ordinary magnetic fields are non-vanishing at it, the total flux vanishes so that there is no observable magnetic field in the scale of cross section. No current is needed to generate the magnetic field in question. This kind of flux tubes are not possible in Maxwell's theory.

In this framework Kotov waves could be seen as a direct support for the magnetic flux tubes along which gravitons propagate. The control action forcing the synchronous oscillations would be by dark matter at gravitational flux tubes and the large value of h_{gr} would make possible coherent oscillations with 160 minute period to have effect on ordinary matter.

4.2 Why is intergalactic gas ionized?

I became aware about new-to-me cosmological anomaly (see <http://tinyurl.com/y6ps6tb8>). FB really tests by tolerance threshold but it is also extremely useful. The news is that the sparsely distributed hot gas in the space between galaxies is ionized. This is difficult to understand: as universe cooled below the temperature at which hydrogen atoms became stable, it should be neutralized in standard cosmology.

In bio-systems there is similar problem. Why biologically important ions are indeed ions at physiological temperatures? Even the understanding of electrolytes is plagued by a similar problem. It sounds like sacrilege to even mention to a fashionable deeply-reductionistic popular physicist talking fluently about Planck scale physics, multiverses, and landscape about the scandalous possibility that electrolytes might involve new physics! The so called cold fusion is however now more or less an empirical fact [L6] (see <http://tinyurl.com/y7u5v7j4>) and takes place in electrolytes - also living matter is an electrolyte.

TGD explanation is based on the hierarchy of Planck constants $h_{eff} = n \times h_0$ predicted by adelic physics as kind of IQ of the system.

- The energy of radiation with very low frequencies - such as EEG frequencies - can be in the range of ionisation energies of atoms by $E = h_{eff} \times f$ - typically in UV range. Hence interaction between long and short length scales characterized by different values of h_{eff} becomes possible and in TGD magnetic body (MB) in long scales would indeed control bio-matter at short scales in this manner. Cyclotron radiation from magnetic flux tubes of MB carrying dark ions would be used as control tool and Josephson radiation from cell membrane would be utilized to transfer sensory input to MB.
- TGD variant of Nottale's hypothesis predicts really large values of h_{eff} . One would have $h_{eff} = h_{gr} = GMm/v_0$ at the magnetic flux tubes connecting masses M and m and carrying gravitons ($v_0 < c$ is a parameter with dimensions of velocity) [L12] (see <http://tinyurl.com/y6317624>). What is important that at gravitational flux tubes cyclotron frequencies would not depend on m being thus universal. For instance, bio-photons with energies in UV and visible range would result from dark photons with large $h_{eff} = h_{gr}$ for frequencies even in EEG range and below.

The ordinary photons resulting from dark photons would ionize biologically important atoms and molecules. In the interstellar space the situation would be the same: dark photons transforming to ordinary higher energy photons would ionize the interstellar gas.

This relates closely to another cosmological mystery.

- Standard model based cosmology cannot explain the origin of magnetic fields appearing in all scales. Magnetic fields require in Maxwell's theory current and in cosmology thermal equilibrium does not allow any currents in long length scales. In TGD however magnetic flux tubes carrying monopole fluxes are possible by the topology of CP_2 . They would have closed 2-surface as cross section rather than disk. They are stable and do not require current to generate the magnetic field. These flux tubes would be carriers of dark matter generating the dark cyclotron radiation ionizing interstellar gas in the scale of wavelength, which would be astrophysical.

2. There are also another kind of magnetic flux tubes for which cross section is sphere but the flux vanishes since the sphere is contractible. these flux tubes are not stable against splitting. There would be no magnetic field in the scale of flux tube. Magnetic field is however non-vanishing and ions in it generate dark cyclotron radiation. These flux tubes would naturally carry gravitons and photons. These flux tubes could mediate gravitational and electromagnetic interactions: gravitons and photons (also dark) would propagate along them.
3. This picture leads to a model for the formation of galaxies as tangles of long monopole flux carrying cosmic strings looking like dipole field in the region of galaxy (for TGD based model of quasars [L20] see <http://tinyurl.com/y2jbru4k>): the energy of these tangle would transform to ordinary matter as the cosmic strings would gradually thicken - this corresponds to cosmic expansion. The process would be the analog of inflation in TGD. Also stars and even planets could be formed in this manner, and thickened cosmic strings would be carriers of dark matter in TGD sense. The model explains the flat galactic rotation curves trivially.
4. Dark ions responsible for the intergalactic ionization could reside at these monopole flux tubes or at the flux tubes which vanishing magnetic flux carrying mediating gravitational interactions. Which option is correct? Or can one consider both options?

There might be a connection with the $T = 160$ minute period appears in astrophysics in many scales from stars to quasars. The observation is that dark cyclotron photons created by Fe^{2+} ions in interstellar magnetic field about .2 nT have period of 160 minutes.

- (a) In TGD inspired biology the endogenous magnetic field is about .2 Gauss and now the time scale is $t = .1$ seconds which corresponds to alpha rhythm, the fundamental bio-rhythm. 160 minutes would correspond to cosmic alpha rhythm! Also cyclotron photons with this frequency could induce ionization of interstellar scales. This would require h_{gr} which is by a factor $T/t = 10^5$ higher. For ordinary alpha frequency M is naturally proportional to the mass of Earth: $M = k_E M_E$. Solar mass is 3.33×10^5 times higher than the solar mass M_S , which suggests that the flux tubes of system with mass of Sun are involved. Could the dark matter in question be associated with the flux tubes connecting Sun to smaller masses in mediating gravitational interaction? The ratio of Planck constants would be

$$\frac{h_{gr,S}}{h_{gr,E}} = \frac{k_S}{k_E} \times \frac{v_{0,E}}{v_{0,S}} \times \frac{M_S}{M_E} .$$

This would demand

$$\frac{k_S}{k_E} \times \frac{v_{0,E}}{v_{0,S}} = \frac{1}{3.33} \simeq 3 .$$

- (b) Note that the 160 minute period was discovered in the dynamics of Sun: no mechanism is not known for an oscillation coherent in so long length scale. Could this mean that the MB of Sun controls dynamics of Sun just as the MB of Earth controls the dynamics of biosphere? Is Sun a conscious, intelligent, entity?

5 Appendix: About the dependence of scattering amplitudes on \hbar_{eff}

In TGD \hbar is replaced with $\hbar_{eff} = nh_0 = nh/6$ [L4, L15, L22], and it is important to know the general dependence of scattering amplitudes on \hbar_{eff} . In QFT formalism the standard choice of units is $\hbar = 1, c = 1$ so that it requires some work to deduce the general dependence of the scattering amplitudes and rate on \hbar_{eff} . One must also check whether this dependence is consistent TGD with view about coupling constant evolution as a discrete sequence of phase transitions between quantum critical states.

5.1 General observations about the dependence of n -particle scattering amplitudes on \hbar

The “*Quantum Field Theory*” by Itzykson and Zuber [B1] provides the information about the general dependence of scattering amplitudes on \hbar albeit in implicit form since units $\hbar = 1, c = 1$ are used.

1. Since putting $\hbar = 1$ is not possible in TGD framework, one must carefully check how the scattering amplitudes and rates depend on \hbar . In this respect tree scattering amplitudes in Abelian gauge theory like QED are characterized by the number of vertices. Each vertex involves g . Besides this there are delta functions expressing on mass shell conditions and momentum conservation.

The amplitude involving n gauge boson-fermion vertices is proportional to g^n and scattering rate is proportional to g^{2n} . g^2 has dimension of \hbar so that the condition that the coupling parameters give dimensionless factor requires additional power of \hbar giving rise to α^{2n} factor, where $\alpha = g^2/4\pi$ is the analog of fine structure constant.

2. The general rule must be that gFF vertex involves factor $g/\sqrt{4\pi\hbar}$. The origin of $1/\sqrt{4\pi\hbar}$ factor can be traced out to the dimensions $[\sqrt{\hbar}/L]$ of scalar and vector boson fields, and the dimension $[\sqrt{\hbar}/L^{3/2}]$ spinor fields following from the condition that Hamiltonian for free fields has dimension $[\hbar/L]$ of energy. This implies that in gauge boson-fermion vertex one has $g/\sqrt{\hbar}$ and in a gauge theory having no dimensional couplings $g/\sqrt{\hbar}$ appears as coupling constant quite generally. In non-abelian gauge theory 3-boson vertices involving g and 4-boson vertices involving g^2 are also present and this rule gives power α^n , $n = n_3 + 2n_4$, where n_3 is the number of 3-vertices (BBB and BBF) and n_4 is the number of bosonic 4-vertices.

This is however gauge theory limit at which particles become points-like and the flux tubes giving rise to a tensor network are neglected. In this framework one could interpret $g^2/4\pi\hbar$ as coupling parameter assignable to the flux tube connecting particles and this is indeed more natural number theoretically since \hbar_{eff}/h_0 is integer. In case of gravitation this seems to be the only possibility.

3. The density of states factor appearing in the rate does not depend on \hbar . In particle-in-the box quantization momenta are given by $p = n\hbar/L$ and density of states is $d^3n = Vd^3p/\hbar^3$. When one scales up \hbar also V is scaled so that d^3n remains invariant.

One can now look the scattering amplitudes and rates in more detail. The “*Quantum Field Theory*” by Itzykson and Zuber [B1] provides examples of practical calculations and allows to deduce simple rules for \hbar dependence of scattering amplitudes and rates.

1. For fermion-fermion scattering in Abelian gauge theories in the lowest order $2 \rightarrow 2$ scattering \hbar disappears from the scattering cross section, and one obtains just the classical result. For instance, electrodynamics lowest order scattering cross sections - say for Compton scattering or electro-electron scattering - are proportional to α^2/m^2 in units $\hbar = 1, c = 1$. Putting in \hbar one obtains $\alpha^2\hbar^2/m^2$. $\alpha = e^2/4\pi\hbar$ implies that \hbar disappears so that its value does not matter. Therefore there is strong dependence on \hbar_{eff} for fermion-fermion in gauge theory in tree approximation. For the radiative corrections to 2-2 scattering coming in powers of α the value of \hbar matters and the larger its value the smaller the corrections are and this gives hopes about the convergence of the perturbation theory. The theoretician friendly Nature would induce a phase transition increasing \hbar_{eff} to guarantee the convergence of perturbation series.
2. For a gauge theory scattering of type $2 \rightarrow n > 2$ via tree diagrams there are n vertices and the total scattering cross section is proportional to α^n/m^2 and thus depends on \hbar for $n > 2$. The rate for production of states with higher particle number decrease with \hbar_{eff} . Hence \hbar is measurable also in this manner.
3. For particle decays the rate is proportional to $1/\hbar_{eff}$: α^2m is the basic dependence from dimensional analysis. Increase of \hbar_{eff} scales up life-time as one might expect. For the decay

of positronium non-perturbative effects due to bound state nature bring in additional power of α and the life time scales like a higher power of \hbar_{eff} .

4. It is often sloppily argued that classical limit corresponds to the limit $\hbar = 0$. This limit however completely fails as an approximation in situations in which $\hbar \rightarrow 0$ limit does not make sense. For instance, for atoms bound state energies are proportional to $1/\hbar^2$ and approach to infinite value as \hbar goes to zero.

Clearly, $2 \rightarrow 2$ scattering for massive particles is very special in that for tree diagrams in QED and gauge theories the outcome does not depend on \hbar_{eff} at all. It is intriguing that $2 \rightarrow 2$ scattering is main provider of information. This leaves room for the possibility of \hbar_{eff} hierarchy.

5.2 Photon-photon scattering as objection against TGD view about discrete coupling constant evolution

Twistor approach suggests in TGD framework that perturbative corrections for a given extension of rationals vanish altogether [K13, K14, K16].

1. The weak form of the proposal is that this occurs only for critical values of coupling constants so that the sum over loop diagrams would vanish in these cases. Coupling constants would depend on extension of rationals and coupling constant evolution would be induced by the hierarchy of these extensions and coupling constant evolution would be discrete. This picture follows if space-time surfaces correspond to zero loci for real or imaginary parts of octonionic polynomials at M^8 side of $M^8 - H$ duality [L7].

One could argue that the hierarchy of extensions of rationals defines a hierarchy of cognitive resolutions obtained by approximation analytic functions of octonions at M^8 side of $M^8 - H$ duality with polynomials. For space-time surfaces represented as zero loci of real or imaginary part of an *arbitrary* analytic function, the radiative corrections would not vanish.

2. Strong form of the proposal would mean that that individual loop corrections vanish identically.

An objection against vanishing of loops is photon-photon scattering, which occurs via box diagram at QFT limit of TGD. This gives for sigma the behavior α^4/E^2 by dimensional argument. The rate is proportional to $1/\hbar_{eff}^2$. Photon-photon scattering is observed and QED predictions are correct.

What the vanishing of loops - in particular box diagrams - at QFT limit TGD could mean for photon-photon scattering? Does this kill the idea about the reduction of scattering amplitudes to tree level?

1. TGD description is based on many-sheeted space-time and the fundamental scattering events in twistor diagrams are for fermions. It is this level at which one would have only the analogs of tree diagrams. QFT limit is only an effective description, and the action is expected to be standard model action in a good approximation. If so, the problem disappears.
2. How photon-photon scattering could emerge at the fundamental level? TGD picture relies on twistor diagrams rather than Feynman diagrams. The proposal is that at fundamental level twistor diagrams at $M^4 \times CP_2$ side of $M^8 - H$ duality involve only fermions and their bound states.

At M^8 side of $M^8 - H$ duality the geometric variant of approach would be realized. Components of super field would correspond to components of super-octonion and polynomial of super-octonion would be analogs of super-field. The vanishing of the real or imaginary part (in quaternionic sense) for the component polynomials would assign to to each component of this super-polynomial a space-time surface in M^8 .

For twistor diagrams the analogs of virtual particles are possible but they would have on-mass-shell complex momenta. Photon-photon scattering could occur as on-mass-shell process in this sense and involve the decay of photon to fermion antifermion pair with complex momenta. Second incoming photon would absorb the antifermion with complex momentum. The reaction would proceed in the similar manner in the remaining two vertices.

5.3 What about quantum gravitation for dark matter with large enough \hbar_{eff} ?

It is interesting to look what \hbar_{gr} hypothesis implies for quantum gravitation for dark matter. Does the QFT type description for quantum gravitation of dark matter make sense in TGD framework?

1. One can consider two identifications for the fundamental parameter as either G or l_P^2 . These identifications lead to same predictions as far the dependence of scattering amplitudes on \hbar_{eff} is considered.
 - (a) G is the fundamental parameter GMm has same dimension $[hbar]$ as $Z_1Z_2e^2$ and thus one can define the analog of gravitational fine structure constant as GM_P^2 . The 2-2 scattering cross section is completely analogous to that for Coulomb scattering and does not depend on \hbar_{eff} at all. This result is rather satisfactory.
 - (b) Second option is that Planck length l_P defines fundamental length and G is identified as $G = l_P^2/\hbar_{eff}$. This gives $GMm = l_P^2Mm/\hbar_{eff}$ with Planck length identified as CP_2 radius R : $l_P = R$ [L18]. The independence of the cross section or $2 \rightarrow 2$ scattering on \hbar_{eff} in lowest order holds true also now. $\sqrt{\hbar_{eff}}M/M_P = \sqrt{GM} = Ml_P/\sqrt{\hbar}$ would serve as analog of e now.
2. In the lowest order the scattering amplitude for $2 \rightarrow 2$ scattering by graviton exchange should be essentially Fourier transform of Newton's gravitational potential at the static limit. The independence of $2 \rightarrow 2$ scattering cross section on \hbar_{eff} looks a natural condition since in the lowest order the scattering would not depend at all on the value of \hbar_{eff} . Coupling strength GMm is analogous to $Z_1Z_2e^2$ and both have dimension $[h]$. Therefore the cross section for $2 \rightarrow 2$ scattering does not depend on \hbar if one expresses $G = l_P^2/\hbar_{eff}$, $l_P = R$. This implies that QFT type description with point-like particles can serve as an approximate description of gravitational interaction.

This and Nottale's proposal [E5] would require that GMm/\hbar_{eff} serves as dimensionless coupling parameter. Coupling strength α_{gr} would characterize pair of interacting particles rather than particle and would be naturally associated with flux tube mediating the interaction as graviton exchange and has an interpretation as generalization of string model picture. This picture makes sense also for gauge bosons.

3. Does the description of two-particle system with masses M and m make sense using Schrödinger equation? De-localization might cause problems and TGD proposal is that only the de-localization of dark matter occurs and also this takes place only on flux tubes along the orbits of planets [K5, K4, K11].

The first observation is that the parameter GMm/\hbar is for planetary systems so huge so that perturbation series fails. $Mm = m_P^2 = \hbar/l_P^2$ serves as an estimate for the upper bound of Mm . For \hbar_{gr} situation changes and one can write the gravitational analog of Schrödinger equation as

$$\left(-\frac{\nabla_u^2}{2} + \frac{\beta_0^2}{u}\right)\Psi = e\Psi, \quad e = \frac{E\beta_0^2}{m}, \quad u = GM = \frac{r_S}{2}. \quad (5.1)$$

$\beta_0 = v_0/c = v_0$ for $c = 1$ clearly occurs in the role of e and the scaling $E = me/\beta_0^2$.

4. If gravitational Schrödinger equation makes sense, the gravitational analogs of atomic transitions should also make sense. For \hbar_{gr} huge pulses of gravitational radiation would accompany the transitions of the gravitational analog of hydrogen atom since binding energies are proportional to mv_0^2/n^2 , m the mass of the planet. What would happen would be emission of dark graviton with energy equal to say energy difference of initial and final states (planetary Bohr orbits), which would then decay to a bunch of ordinary gravitons [K4].

One could estimate the rate of transitions using the existing results from atomic physics. One can also try to estimate the transition rate from a generalization of Uncertainty Principle (UP): $\Delta T = \hbar_{gr}/\Delta E$. Order of magnitude is about GMn^2/v_0^3 ($c = 1$). This gives $10^5 n^2$

seconds for $v_0/c = 2^{-11}$. This time is of order 30 hours! The transition would be associated with dark matter. This looks totally unrealistic. This estimate makes sense only if there is de-localization of dark matter to analogs of hydrogen orbitals.

A better estimate should include the interaction with dark graviton field rather than mere UP. Here one can use Fermi's Golden Rule (see <http://tinyurl.com/yblec2on>). The change of energy would be huge and therefore also graviton's energy and momentum. Wave vector however matters and would be give by $k = p/\hbar_{gr}$ and de Broglie wavelength would be of order of planetary orbit so that the analog of dipole approximation $exp(ik \cdot x) = 1 + ik \cdot x$ would make sense. The time for transition would be about $\Delta T = \hbar_{gr} \Delta E / E^2$ and of the same order of magnitude as previous estimate. This does not make sense. De-localization of dark parts of planets in the scale of solar system would lead to surreal effects.

5. In TGD picture the dark matter is assumed to be de-localized only at the flux tubes associated with planetary orbits. TGD approach relies on zero energy ontology (ZEO) in which quantum states correspond to quantum superpositions of preferred extremals of action (sum of Kähler action and volume term proportional to cosmological constant). The transition would involve classical orbits transforming to each other by dark graviton emission. The transition would occur as a replacement of flux tube trajectory with given energy with a trajectory having lower energy. If one assumes Bohr quantization for the trajectories, the energy liberated as dark graviton in the transition is huge using normal standards for quantum transitions.

The basic condition is that the trajectories intersect. For instance, if the original trajectory is circle, the final trajectory could be ellipsoidal trajectory with a lower energy and located inside the circular trajectory and touching it at diametrically opposite points. A natural expectation is that the transition rate is proportional to $P = (V_{12}/\sqrt{V_1 V_2})^2$, where V_{12} is the volume shared by the two flux tubes V_i are flux tube volumes. The square roots $\sqrt{V_i}$ of the flux tube volumes would correspond to normalization factors for dark matter wave functions at flux tubes. The square of this factor would give a very small coefficient and make the transition very slow despite the factor that the dimensionless coupling analogous to α would be $\beta_0/4\pi$.

One would have $V_{12} \sim d^3$, where d is flux tube thickness. Flux tube volume would be $2\pi^2 R d^2$ so that one would have order of magnitude estimate $P \sim (1/4\pi^4)(d/R)^2$ determined by the ratio of the thickness of the flux tube to the area of the orbit determined by it. If the thickness of the flux tube is of the order of planet radius, P for Earth has order of magnitude 10^{-11} . By multiplying the estimate about 30 hours given by Uncertainty Principle would obtain a rough estimate 10^9 years for the lifetime of the flux tube orbit of Earth.

This kind of transitions should correspond to "big" state function reductions analogous to ordinary quantum measurements rather than "small" state function reductions having so called weak measurements (see <http://tinyurl.com/zt36hpb>) as analogs. In "big" state function reductions the arrow of geometric time changes in the sense that the roles of passive and active boundary of causal diamond (CD) change and the sequence of weak measurements occurs at opposite boundary of CD shifting farther away from the passive boundary, which was active boundary before the "big" state function reduction. Note that the temporal distance between the tips of CD increases and gives rise to clock time as a counterpart of experienced time defined by the sequence of "small" state function reductions)

6. For QFT description of quantum gravitation $\sqrt{\hbar}E/M_P = El_P/\sqrt{\hbar} = E\sqrt{G}$ would serve the role of the coupling parameter analogous to e . To get some idea what happens one can look graviton-graviton scattering amplitude for 4 gravitons having all 2 positive 2 negative helicities and known as $M^{- - + +}$. Lowest order calculations without loops at Minkowski limit (tree diagrams, see <http://tinyurl.com/y82rsw9y>) give an expression as a sum of terms proportional to x^2 , where the dimensionless variable x is $x = El_P/\sqrt{\hbar_{eff}}$: E is energy scale. Amplitude is proportional $1/\hbar_{eff}$ and the scattering amplitude approaches zero for large values of \hbar_{eff} .

5.4 A little sidetrack: How a finite number of terms in perturbation expansion can give a good approximation although perturbation series fails to converge?

The perturbative expansion of electrodynamics does not converge. This looks paradoxical since the predictions of QED are extremely accurate. This statement is of course somewhat sloppy since there are many notions of convergence. For instance, converge could occur in some kinematical regions and fail to do so in some other regions.

If convergence does not occur in kinematically important regions, how can then apply the perturbative expansion at all? Part of the explanation is certainly that in $2 \rightarrow 2$ scattering the lowest order does not depend on \hbar at all so that it could be calculated by using so large a value of \hbar that convergence occurs. Could one take the convergent result cut to a finite number of powers of α in convergence region and continue it by replacing α with its actual value to region where the convergence fails? Finite cutoffs would not deviate much from the correct result but the remainder would be infinite.

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