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

M. Pitkänen,

February 2, 2024
Email: matpitka6@gmail.com.
http://tgdtheory.com/public_html/.
Postal address: Rinnekatu 2-4 A 8, 03620, Karkkila, Finland. ORCID: 0000-0002-8051-4364.

Contents

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 $h_{eff} = h_{gr}$. 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 this region! Could G have several values? This suggests the generalization $G = l_P^2/\hbar \to G = R^2/\hbar_{eff}$ 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 $G = R^2/h_{eff}$ with h_{eff}/h_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 $h_{eff} = nh_0$, $h = 6h_0$ together with the condition that theory contains CP_2 size scale R as only fundamental length scale, suggest the possibility that Newtons constant is given by $G = R^2/\hbar_{eff}$, where R replaces Planck length ($l_P = \sqrt{\hbar G} \to l_P = R$) and $\hbar_{eff}/h$ 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 $h_{eff} = h_{gr} = GMm/v0$ 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 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.

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 [L19], 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 [L26].

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

Nottale's formula [E6] 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 [K20, K13, K14, **?**] 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 [L25] [L25, L24, L28].

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 $L_{ind} < L_{M^4}$. 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 $V_{M^4} = (4\pi/3)L^3_{M^4}$ 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 Schwartschild 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 [K19] 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 $h_{eff} \to xh_{eff}$ inducing $G \to G/x$ and $t \to t/x, r \to r/x$ 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 [E10] (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 1978.

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/m^2. 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 Newtons constant is given by $G = R^2/\hbar_{eff}$, where R replaces Planck length ($l_P = \sqrt{\hbar G} \rightarrow l_P = R$) and $\hbar_{eff}/h$ 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 a continuous scale invariance to a discrete one.

In the special case $h_{eff} = h_{gr} = GMm/v0$ - gravitational Planck constant originally introduced by Nottale [E6]- 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.

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

Nottale's formula [E6] 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 [K20, K13, K14, **?**] 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 [L25] [L25, L24, L28].

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 $L_{ind} < L_{M^4}$. 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 $V_{M^4} = (4\pi/3)L^3_{M^4}$ 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 Schwartschild 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 [K19] 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 $h_{eff} \to xh_{eff}$ inducing $G \to G/x$ and $t \to t/x, r \to r/x$ with scales up the size scale of space-time sheets as the proportionality of Compton length to h_{eff} requires.

2.1 Formula for the gravitational Planck constant and some background

The formula

$$\hbar_{gr} = \frac{GMm}{v_0} \tag{2.1}$$

for the gravitational Planck constant was originally introduced by Nottale [E6]. 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

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

The support for the formula $h = 6h_0$ is discussed in [L5, L21]. 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 [L13].

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 [K24, K19, K2]. 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 [K20, K13] 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 [L25] [L25, L24, L28].

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 [L16]. 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 [L16], 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 $V_{M^4} = (4\pi/3)L^3_{M^4}$ at the passive boundary. The condition $\rho = \epsilon^2\rho_{cr}$ allows to solve $\beta = L/L_H$ as

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

   Here r_S is Schwartschild 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 passsive boundary of CD. Option II is obtained at the limit $\epsilon_! = 1$.

Consider first Sun.

1. In the case of Sun the model for the Bohr quantization of planetary orbits was originally proposed by Nottale [E6] and was developed further in TGD framework in [K20, K13] 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 $\beta_0(inner) = 2^{-11}$ for the 4 inner planets and $\beta_0(out) = \beta_0(inner)/5$ for the outer planets.

2. For the 4 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 $v_0 \to v_0/5$ scales the radius by factor 5^2. This also means that scaling $n \to kn$ and scaling $v_0 \to v_0/k$ produces the same scaled orbital radius.

3. For the 4 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 Schwartschild radius of Earth is $r_S = 9$ mm.

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

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

The condition $\beta_0(I) = 2^{-11}$ is marginally consistent with the biology related considerations of [L20] 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 $\beta(I) \to \beta/8$ inducing the scaling $R_E \to 64R_E > 60.3R_E$. 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

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

   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

$$a = a_{gr,D} n_D^2 \quad , \quad a_{gr} = \tfrac{4\pi G M_D}{v_0^2} \quad . \tag{2.5}$$

   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

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

   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 [L20] 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 $5.52 \times \rho_W$, $\rho_W =$ 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 [K24, K2, K19, K26] 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 [L5, L21]. At flux tubes mediating gravitational interactions one has

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

   where v_0 is a parameter with dimensions of velocity. I recently proposed a concrete physical interpretation for v_0 [L19] (see `http://tinyurl.com/yclefxb2`). 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 $\hbar_{eff,f} = h_{gr}$.

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 $Z_1 Z_2 e^2/4\pi\hbar = Z_1 Z_2 \alpha$, $\alpha \simeq 1/137$.

2. As shown in [K20, K13, K14, ?] one can also define gravitational fine structure constant α_{gr}. Only α_{gr} should matter in quantum gravitational scattering amplitudes. α_{gr} wold be given by

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

   $v_0/4\pi$ 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.

3. The proposed physical interpretation is that a phase transition $\hbar_{eff,i} \to \hbar_{eff,f} = h_{gr}$ 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 naïve first guess for this value). Nature would be theoretician friendly and increase h_{eff} and reducing α_{gr} so that perturbation series converges again.

   Number theoretically this means the increase of algebraic complexity as the dimension $n = h_{eff}/h_0$ of the extension of rationals involved increases fron n_i to n_f [L9] 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 $Z_1Z_2\alpha$ is so large that perturbation theory fails. The replacement $\hbar \to Z_1Z_2e^2/v_0$ 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 $(GmMm/Z_1Z_2e^2)(v_0/4\pi)$.

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

1. 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.

2. 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

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

   under $h_{eff} \to xh_{eff}$ would be achieved by scaling $\overline{r} \to \overline{r}/x$ and $t \to t/x$. 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 $h_{eff} \to xh_{eff}$!

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 to the field equations for Kähler action approximate spherically symmetric stationary solutions [K27]. The naïve 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 [K12] and work with cosmic strings [K5] 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 $\hbar \to \hbar_{eff}$ 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 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 [E10] (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 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.

3.1 The experiments

The experiments use torsion pendulum: this method was introduced by Henry Cavendish in 1978.

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 $\mathrm{N/m^2}$. 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 [L19] (see `http://tinyurl.com/yclefxb2`). 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 h_{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 $\hbar_{eff}(gr)/h_{min} \simeq 2^{24}$. $\hbar_{eff}(gr)$ should not be confused with $\hbar_{gr} = GMm/v_0$ proposed by Nottale [E6] which for $M = M_E$ and $m = 2m_p$ is much larger.

Remark: This raises a problem to be discussed in the application to fountain effect. $h_{eff}(gr)$ 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 $h_{eff}/h = n$ 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 $h_{eff}/\hbar$ by scaling lengths by $n/n_0 = n/6$ [L5, L21, 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. h_{eff} has spectrum and as a special case one has $\hbar_{eff} = h_{gr} = GMm/v_0$. Is this case 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 $\hbar_{eff} = h_{gr} = GMm/v_0$ 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 4 inner planets [K20, K14].

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 $h_{eff}/h = n$ 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 [L14, L15]. 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 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 [K24, K19] [L19]. 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/yclefxb2`).

As already explained, the maximum for the variation of G is 500 ppm $= 5 \times 10^{-4}$. 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 $k \to k+1$, for a prime factor k of n. 47 ppm would give $k \simeq 2,128$. For $k = 2^{11} \to k-1$ 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 $h_{eff}/\hbar$ 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 h_{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 subgoups 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 $h_{eff}/h = n$

. 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 notin 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 $H_1 \subset H_2 \subset ...$ define a hierarchy of extensions $E^{H_1} > E^{H_2} > E^{H_3}...$ 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 $O(logN/N)$, 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 naïvely, 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 [L9] 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 an write closed expressions in terms of radicals as Galois found? Could it be that the polynomials obtained by a 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 $1 < G_0 < G_1 ... < G_k$ 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 $G \triangleright G^{(1)} \triangleright G^{(2)} \triangleright ...$ 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, L27]. 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 [L9] 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 or delocalization due to a large value of h_{eff}?

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, in the well-known fountain effect (`http://tinyurl.com/kx3t52r`) of superfluidity, superfluid seems to defy gravitation. I have asked whether $h_{eff}/h_0 = n$ increases at superfluid flux tubes to h_{gr} and this gives to the effect as a de-localization in much longer scale [**?**]. The delocalization could be also due to the reductionof h_{em} or possibly h_Z assignable to long range classical Z^0 force predicted by TGD.

If G is reduced - this means violation of Equivalence Principle in its standard form - 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.

A simple model for the situation discussed in [**?**] 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.

1. One obtains 1-dimensional Schrödinger equation

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

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

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

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

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

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

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

(3.2)

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

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

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

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 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

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

   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.

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

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

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

   The gravitational Compton length λ_{gr} is given by $\lambda_{gr} = GM_e/v_0 = r_S/2v_0$ and - in accordance with the Equivalence Principle - does not depend on m. The Schwartschild radius of Earth is $r_S = .9$ cm. One could argue that λ_{gr} is a reasonable lower bound for z_0 if h_{gr} appears in the gravitational Schrödinger equation. For $v_0/c = 2^{-11}$ required by the Bohr orbit model for the inner planets, this would give $\lambda_{gr} = 9$ m. The energy scale of dark cyclotron states comes out correctly if one has $v_0/c = 1/2$ giving the lower bound $z_0 \geq r_S = .9$ cm.

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

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

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

Podkletnov observed [H3] 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 a superconductor involving also the 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? The mechanism could be the same as in the fountain effect. The non-standard value of h_{em} could induce delocalization and reduction of g. Now also a small change g from its normal value can be considered and would have been few per cent in this case. This would mean a small breaking of

3.6 Did LIGO observe non-standard value of G and are galactic blackholes 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 [L6, L4] (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.

(a) 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.

(b) 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 $E^2G(M+m)^2$, 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 naïvely 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 Schwartschild radius, although the classical dynamics does not allow this.

(c) 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 blacholes?

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.

(a) 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

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

(b) 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.

(c) 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.

(a) 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.

(b) 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 tells 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.

(c) 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 eequation.

(d) 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 generate 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 $massm_2$ 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?

(a) 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.

(b) 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.

(c) 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?

(a) 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 $h_{gr}/\hbar$.

(b) What can one say in TGD framework about the values of phases Φ?

i. For $\hbar \to \hbar_{eff}$ one would have

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

For $\hbar \to \hbar_{eff}$ the phase differences would be reduced for given Δt. On the other hand, quantum gravitational coherence time is expected to increase like

h_{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.

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

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

If Planck length is actually equal to CP_2 length $R \sim 10^{3.5}\sqrt{G_N\hbar}$, one would has $G_N = R^2/\hbar_{eff}$, $\hbar_{eff} \sim 10^7$. 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 $h_{eff} = h_{gr}$.

iii. 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 Fluctuations of Newton's constant in sub-millimeter scales

Sabine Hossenfelder had a post with link to an article "*Hints of Modified Gravity in Cosmos and in the Lab?*" [E9] (see `http://tinyurl.com/y6j8sntw`). Here is the part of abstract that I find the most interesting.

On sub-millimeter scales we show an analysis of the data of the Washington experiment (Kapner et al. (2007) searching for modifications of Newton's Law on sub-millimeter scales and demonstrate that a spatially oscillating signal is hidden in this dataset. We show that even though this signal cannot be explained in the context of standard modified theories (viable scalar tensor and f(R) theories), it is a rather generic prediction of nonlocal gravity theories.

What is interesting from TGD point of view that the effect - if it is indeed real - appears in scale of .085 mm about 10^{-4} μm, which is the scale defined by the density of dark energy in recent universe and thus by cosmological constant. This is also size scale of large neuron.

3.8.1 Findings

Washington group studied gravitational torque on torque pendulum for sub-millimeter distances of masses involved [E7] (see `http://tinyurl.com/y2un6686`). Figure 19 of [E9] (see `http://tinyurl.com/y6j8sntw`) illustrates data points representing the deviation of the gravitational torque from the Newtonian prediction as a function of distance in the range .05-10 mm.

The deviation can parameterized in terms of effective scaling $G \to kG$ of Newton's constant, which is assumed to be predictable rather than due to fluctuations and depend on the distance only

$$k = 1 + xcos(\frac{2\pi r}{\lambda} + \frac{3\pi}{4}) \quad .$$

x is a numerical parameter. The highly non-trivial assumption is that Newton's potential is modified by an oscillating term, which must go to zero at large distances: its amplitude could approach to zero like $1/r$. The model predicts an anomalous gravitational torque $\Delta\tau$ proportional to $k-1$ and having the form

$$\Delta\tau = acos(\frac{2\pi r}{\lambda} + \frac{3\pi}{4}) \quad ,$$

where r is the distance between the masses. The parameter $\lambda = \hbar/m$ is formally analogous to Compton length for imaginary mass m.

The finding is that the statistical significance for the best fit to the data is $(a, \lambda) = (0.004\ \ fNm, 65\ \ mm^{-1})$ is more than 3σ, where a is the amplitude of the deviation. The highly non-trivial problem is however that one obtains also other minima of χ^2 measuring the goodness of the fit with different values of the parameter λ.

I am not specialist but while looking at the data, I cannot avoid the feeling that the fit does not make much sense and reflects theoretical prejudices (belief in modified gravity of some kind) rather than reality. My first impression that fluctuations in the value of Newton's constant G are in question. The value of G is indeed known to vary from experiment to experiment and the variation is too large to be explained in terms of measurement inaccuracies [**?**]see `http://tinyurl.com/yanvzxj6`).

Could it be that the value of G fluctuates, and for some reason in the length scale range around .1 mm the fluctuations are especially large meaning different values of G are large? Could some kind of criticality enhanced rather dramatically below .1 mm be involved?

3.8.2 Could fluctuations in the value of G explain the findings?

Twistor lift of TGD [K24, K19, K2, K26] predicts that cosmological constant is length scale dependent and that Newton's constant G has a spectrum reflecting the spectrum of effective Planck constant $h_{eff} = nh_0$ ($h = 6h_0$ is a good guess [L5]): dark matter would correspond to $h_{eff} = nh_0$ phases of ordinary matter.

p-Adic length scale hypothesis allows to assign to cosmological constant Λ two length scales: the cosmological p-adic scale defined by Λ itself and the short p-adic length scale determined by the density of dark energy so that physics is cosmological scales and physics in microscopic scales reflect each other.

This encourages the idea that one might understand the experimental findings in terms of fluctuations of G induced by quantum fluctuations of h_{eff} at quantum criticality.

(a) TGD suggests a spectrum for the values of G. The starting points is the expression for the effective Planck constant ass $h_{eff} = n \times h_0$. In adelic physics the value of n is identified as the number of sheets for the space-time surface as covering space and would correspond to the order of Galois group of extension of rationals inducing the extensions of p-adic number fields appearing in the adele [L14, L15].

(b) An additional hypothesis is that space-time surface can be regarded as covering of both M^4 and CP_2 with numbers of sheets equal to n_1 and n_2: $n = n_1 n_2$. The number of sheets over M^4 would be n_1 so that CP_2 coordinates would be n_1-valued functions of M^4 coordinates. The number of sheets over CP_2 would be n_2 and one would have effective n_2 copies of n_1 valued regions in M^4.

The gravitational Planck constant $\hbar_{gr} = GMm/v_0$ originally introduced by Nottale [E6] is proposed to correspond to $\hbar_{eff} = \hbar_{gr} = n_1 n_2 \hbar_0$. The real Planck length $l_P(real)$ would correspond to $l_P(real) = R$, the CP_2 size scale identified as geodesic length, and Newton's constant would correspond to

$$G = \frac{R^2}{\hbar_1} = \frac{R^2}{n_1 \hbar_0} \quad .$$

One would have $n_1 \sim 6 \times 10^7$ from $l_P^2/R^2 \sim 10^7$.

(c) The value of n_1 can fluctuate and induce fluctuations of G. The fluctuations could be even large. One can even ask whether the fountain effect of superfluidity involves a large value of n_1 responsible for macroscopic quantum coherence and due to the increase of the value of $\hbar eff$ caused the increase of n_1 in turn reducing the value of G [**?**].

Could the fluctuations of n_1 explain the findings about the value of G deduced from Washington experiment? The appearance of several values for parameter λ might signal about fluctuations of G rather than modification of the radial dependence of gravitational potential.

Why the fluctuations in the value of G would be so large in sub-millimeter length scales?

(a) Cosmological constant $\Lambda \simeq 1.1 \times 10^{-52}$ m^{-2} has dimension of $1/L^2$, L length scale. The density of dark energy $\rho_{vac} = \Lambda/8\pi G$ has dimensions of $\hbar/L^4$. One can assign to Λ very long p-adic length scale $L(k_1) = 2^{k_1/2}R$ ($p_1 \simeq 2^{k_1}$), and to $\rho_{vac}/\hbar$ rather short p-adic length scale $L(k_2) = 2^{k_2/2}R$. One has

$$\frac{\rho_{vac}}{\hbar} = \frac{x_2}{L(k_2)^4} = \frac{x_1}{8\pi}\frac{1}{l_P^2 L(k_1)^2} \quad ,$$

where x_1 and x_2 are numerical constants not far from unity. This would give

$$L(k_2) = (8\pi\frac{x_2}{x_1})^{1/4}(L(k_1)l_P)^{1/2} \quad .$$

$L(k_2)$ would be proportional the geometric mean of $L(k_1)$ and l_P. This implies

$$2^{2k_2} = \frac{x_2}{x_1} \times 8\pi \times (\frac{l_P}{R})^2 2^{k_1} \quad .$$

Very roughly, $k_1 \sim 2k_2 - 26$ would hold true for $x_2/x_1 \sim 1$. It turns out that k_2 corresponds to a p-adic length scale about 10^{-4} meters, which happens to be the size of large neuron suggesting that quantum gravitation is indeed highly relevant to biology but in manner different from that speculated by Penrose.

(b) p-Adic fractality suggests that cosmological constant is not actually constant or even time varying but depends on p-adic length scales so that the values are indeed extremely large as one approaches CP_2 scale and get very small as one approaches cosmological scales. This would solve the cosmological constant problem. The dependence would be $\Lambda(k) \propto 1/L(k)^2$, where $L(k)$ is the p-adic length scale characterizing the size of the space-time sheet. There would be a sequence of phase transition reducing Λ and these phase transition would involve quantum criticality and long length scale fluctuations possibly assignable to those of h_{eff} and thus of n_2 and G.

If one assumes that k_2 corresponds to preferred p-adic lengths scales assignable to elementary particles, nuclei, atomic physics and biology, one obtains a prediction that the corresponding p-adic length scales correspond to cosmologically important length scales via $k_1 \sim 2k_2$. One could study cosmology by studying gravitation in laboratory scales!

In these scales quantum phase transitions changing cosmological constant could make themselves visible via microscopic physics. Phase transitions involve long length scale fluctuations characteristic for criticality. In TGD these quantum fluctuations correspond to fluctuations of h_{eff} since Compton lengths scale like h_{eff}. The fluctuations of n_1 in $n = \hbar_{eff}/\hbar = n_1 n_2$ would induce fluctuations of G.

(c) Especially interesting are the p-adic length scales which are biologically important. The number theoretical miracle is that there are as many as 4 very closely located Gaussian Mersenne primes $M_{G,n} = (1+i)^m - 1$ in the range of cell membrane thickness and size of cell nucleus corresponding to $k = 151, 157, 163, 167$. The corresponding p-adic length scales $L(k) = 2^{(k-151)/2}L(151)$, $L(151) \simeq 10$ nm could be also gravitationally especially interesting. The hierarchical coiling of DNA might relate to the hierarchy of Gaussian Mersennes and phase transitions changing cosmological constant and the density of magnetic and volume energies assignable to the magnetic flux tubes playing

key role in TGD inspired biology. These phase transitions would scale the thickness of the flux tubes determined by p-adic lengths scale.

It should be relatively easy to check whether the p-adic length scale hierarchy up to biological length scales has scaled variant in astrophysical and cosmological scales.

3.9 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 [L16] I can take the liberty to talk also about these effects, even at personal level.

(a) 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.

(b) 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 $h_{eff}/h = n$ 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 $h_{eff}/h = n$ for some part of magnetic body would explain this.

(c) 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.

(d) 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 Three alternative generalizations of Nottale's hypothesis in TGD framework

Gravitational Planck constant $h_{gr} = GMm/v_0$ was originally introduced by [E6] and its form realizes Equivalence Principle (EP) in its Newtonian form (gravitational acceleration does not depend on mass m). The generalization of the idea was formulated in the TGD framework in [K20, K13]. $h_{eff} = nh_0 = h_{gr}$ would characterize the U-shaped flux tube tentacles emanating from M and mediating gravitational interaction.

One implication is that the parameter $v_0/c = \beta_0 < 1$ appears as a natural expansion parameter of the gravitational scattering amplitudes in the perturbative expansion replacing GMm. There is no dependence of GMm. Note that $\hbar_{gr} \geq h$ requires $GMm \geq v_0$.

$v_0 \simeq 2^{-11}$ suggested by the Nottale's Bohr orbit model for the 4 inner planets and is consistent with the model for the fountain effect of superfluidity [K6]. Indeed, the gravitational Compton length of the superfluid particle is $GM/v_0 \simeq 10$ m, which makes sense.

However, the model has a problem. For $M = M_E$, the cyclotron energies $\hbar_{gr} eB_{end}/m$ of dark ions in the endogenous magnetic field $B_{end} = 2/5B_E = .2$ Gauss explaining the findings of Blackman [**?**] in terms of the $h_{eff} = nh_0 = h_{gr}$ hypothesis would be given by $E_c = GM_E/v_0 \times ZeB_{end}$ and would not depend on the mass m of the charged particle. For $\beta_0 \simeq 2^{-11}$ E_c would be in keV range and 3-4 orders of magnitude above visible range. Biophoton energies are however in visible and UV range.

4.1 Three ways to solve the problem of the too large cyclotron energy scale

One can imagine three ways to solve the too large cyclotron energy scale.

(a) The dark mass M_D is by 3-4 orders of magnitude smaller than the mass M_E of Earth. Here one should be able to understand why dark particles couple only to a part of M_E.

(b) Gravitational constant G_D for dark mass is by 3-4 orders of magnitude smaller than G. This would mean a violation of Equivalence Principle (EP). In the TGD framework, G indeed follows as a prediction and might vary [K1]. This could also provide an alternative explanation for the fountain effect.

(c) The velocity parameter $\beta_0 = v_0/c \leq 1$ has the value $\beta_0 = 1$ or is near to but below this value. For instance $\beta_0 = 1/2$ is enough. This option is favored by the Nottale's Bohr orbit model of the planetary system. The outer planets β_0 indeed varies: one has $\beta_0(outer) = \beta_0(inner)/5$. One has also $M = M_D$ and $G = G_D$.

4.1.1 Can dark mass M_D be smaller than the total mass M?

The model [K16] for the effects of ELF radiation on vertebrate brain [**?**] led to a generalization of Nottale's hypothesis by replacing the total mass M in the case of Earth by $M_D \simeq 10^{-4} M_E$ suggesting that in this case the dark particles involved couple only to a part of mass identifiable as dark mass M_D.

A possible interpretation is that at long distance from mass M the flux tubes fused to larger flux tubes and the gravitational mass M_D interacting with the test particle increases to M at large distances. This might be in conflict with known facts.

The dark mass M_D appearing in the gravitational Planck constant $h_{eff} = h_{gr} = GM_D m/v_0$ must at short distances depend approximately linearly on the distance between the masses M_D and m . In the average sense. M_D would depend linearly on distance r. This is required by the condition that the Bohr radii correspond to the classical radii in the average sense. The actual dependence of M_D on r is expected to be a staircase like function.

At the quantum level, this effectively eliminates the average gravitational force in scales below the critical radius r_{cr} above which $M_D = M$ is true. Indeed, due to the average $M_D \propto r$ dependence, gravitational potential would be constant on the average. Could one regard this effective elimination of the gravitational force as a kind of Quantum EP or as an analog of asymptotic freedom?

4.1.2 Or could the value of G be reduced to $G_D < G$?

The reduction of $\hbar_{gr}$ could be also due to the reduction G to G_D. This is because only the parameter GM appears in the basic formulas.

(a) In the TGD framework Planck length as a fundamental length is replaced by CP_2 length R and Planck length or rather, Newton's constant G follows as a prediction. One can write

$$G = \frac{\hbar_{gr}\beta_0}{Mm} \quad .$$

(b) In the number theoretic vision about h_{eff} one can identify $\hbar_{gr}$ as the dimension of the Galois group of an extension of rationals [L38]. Since one has in the general case extension of extension of ...of rationals, one has a factorization $\hbar_{gr}/h_0 = \prod_i n_i$ where n_i are dimensions of extensions of extensions in the sequence.

This suggests that Mm corresponds to an integer in suitable units, say CP_2 length $R \simeq 10^{3.5} m_{Pl}$ and β_0 could also correspond to inverse of integer. $\hbar_{gr}$ would correspond to an integer and the reduction of G to G_D would correspond to a dropping of integer factor from this integer.

(c) $\hbar_{gr}$ would factorize to integers assignable to M and m and the integer assignable to G would be reduced in $G \to G_D$. If this integer factorized into a product assignable to M and m characterizing their gravitational couplings, one could understand why the reduction of G occurs only for superfluidity and dark phases in living matter. No additional assumptions about flux tube distribution would be needed.

4.1.3 Does variable β option make sense?

The third option would assume $\beta_0 = 1$ or near to but of order $\beta_0 = 2^{-11}$ for the dark ions in living matter. This conforms with the idea that dark dark matter interacts with all matter and satisfies EP.

The value of β_0 could be seen as the property of the dark matter particle and depend on the particle or on the distance from the central object as in the case of the solar system.

Gravitational Compton length l_{gr} Bohr orbit radius a_{gr} are given by $l_{gr} = GM/v_0 = r_S/2v_0$ and $a_{gr} = 2\pi r_S/v_0^2$. The reduction of β_0 scales up the quantum scale considered. Could this give some idea about how the value of β_0 relates to the size scale of the system considered? For the dark ions at magnetic flux tubes the l_{gr} would be about $r_S/2 \simeq .45$ cm, which is a biological scale. Could it correspond to the size scale of some structure of the vertebrate brain, say pineal gland with radius .37 cm?

In the sequel these options will be considered. I try to not take any of these options as a favorite but I must admit that the last option looks the most plausible one - at least now.

4.2 Could $M_D < M$ make sense?

For the generalization of the Nottale hypothesis discussed in the introduction, the gravitational Planck constant $\hbar_{gr} = GM_D m/v_0$ introduced by Nottale [E6] is proportional to dark mass M_D which is in general would be smaller than the entire mass M.

Remark: As noticed in the introduction, it is GM that appears in h_{gr}, so that an alternative option is that G is reduced G_D. It would naturally characterize mass m rather than flux tube. Violation of Equivalence Principle would be in question.

Dark cyclotron energies $E_c = \hbar_{gr} eB_{end}/m = GM_D eB/v_0$ do not depend on the mass of the particle. The condition that the cyclotron frequencies in EEG range correspond to biophoton energy scale in visible and UV range for $B_{end} = .2$ Gauss, gives the estimate $M_D \simeq 2 \times 10^{-4} M_E < M_E$. One proposal is that M_D corresponds to the mass of the inner-inner core of Earth: see the appendix of [L44].

This raises the question about how the gravitational flux tubes emanating from mass M and connecting it to small masses m - say elementary particles, atoms of ions - are distributed. At short distances, the entire mass would not be connected to a given mass m by this kind of flux tubes. Does the amount M_D of the mass connected to mass m depend on the distance between m and M? How the allowed values of m are distributed and do they depend on distance? For instance, the condition $GM_D m/v_0 > \hbar$ must be satisfied.

Remark: One can argue that radial magnetic flux tubes are not realistic. One can also consider the possibility that U-shaped flux tubes acting as kind of tentacles in TGD inspired quantum biology, are in question so that magnetic flux would return back. The fusion of flux tubes to larger flux tubes at longer distances makes sense also now.

4.2.1 Some guide lines

There are several hints, which suggest answers to some of these questions.

(a) In the TGD variant [K20] of the Bohr model for the planetary orbits [E6] around Sun, the dark mass M_D for Sun equals to solar mass: $M_D = M_{Sun}$. This suggests that at large enough distances M_D approaches the total mass M of the object. One can imagine that the flux tubes from M fuse to larger flux tubes so that m experiences $h_{gr} \propto M_{Sun}$ at large distances.

(b) In the Bohr orbit model of the planetary system in the gravitational potential of mass M_D, the gravitational binding energy of mass m at the lowest Bohr orbit with $n = 1$ is proportional to $\alpha_{gr}^2 m/2 = mv_0^2/8\pi^2$ ($\alpha_{gr} = v_0/4\pi$) and does not depend on M_D at all. This is true also for higher orbits with $n > 1$.

The consistency with the classical formula for the potential energy $V_{gr}(r) = GM_D m/r$ suggests that M_D is in average sense proportional to the distance between M and m at small distances.

The radius r_B of the gravitational Bohr orbit is $r_B = \hbar_{gr}/\alpha_{gr} m = 4\pi GM_D/v_0^2$ and does not depend on m at all (note that $2GM_D$ is the Schwartchild radius associated with M_D). The larger the value of M_D, the larger the distance of m to M. This supports $M_D \propto r$ proportionality at small distances in average sense. There is some distance at which the value of M_D reaches M and does not grow anymore.

These arguments suggest that $M_D \propto r$ holds true in a reasonable approximation and that the gravitational flux tubes from smaller parts of M fuse to form larger flux tubes corresponding to the sum of the masses. A particle at a small distance would experience only part of the gravitational force created by M.

M_D/r would be constant on the average sense below the critical radius R_{cr} at which M_D becomes M and the values of M_D would form a linear staircase. At a given step of the staircase, the value of M_D would be constant and M_D/r would decrease. The radial gravitational force averaged over the staircase would vanish. In the average sense, one would have a free particle in a box.

Taking seriously the identification of M_D at the surface of Earth as the mass of the inner-inner core of the Earth, leads to ask whether the gravitational staircase could correlate with the layered structure of the Earth's interior.

Gravitational force is effectively eliminated below R_{cr}. Could this be interpreted in terms of Quantum Equivalence Principle? Asymptotic freedom is another analogy that pops in mind.

4.2.2 Magnetospheric sensory representations as a test of the proposal

This proposal can be tested in the TGD based model for sensory representations realized at magnetosphere [K11, K10].

(a) The proposal is that the magnetosphere of Earth defines sensory representations for the life forms at the surface of Earth. The communication and control would rely on dark photons with energies $E = h_{gr} f$ above thermal energy at physiological temperatures. For energies in visible and UV range dark photons can induce molecular transitions crucial for biochemistry by transforming to ordinary photons identifiable as biophotons [K3, K4].

(b) The energetic condition should be true near the surface of Earth, inside the rotating inner magnetosphere, and also in the outer magnetosphere extending to the distance of order $200R_E$. In plasma sheet, the order of magnitude for B is $B \sim 10 - 20$ nTesla. One has $B/B_{end} \sim 5 \times 10^{-4}$ for $B = 10$ nTesla.

(c) The cyclotron energies are given by $E_c = GM_D eB/v_0$ and do not depend on m. At the surface of Earth one has $M_D \simeq 2 \times 10^{-4} M_E$. At large enough distances one has $M_D = M_E$. In the outer magnetosphere this is expected to be true.

This would give $E_c(outer) = (M/M_D) \times (B/B_{end}) E_c(Earth) \simeq 2.5 E_c(Earth)$. The cyclotron energies would be of the same order of magnitude as required.

(d) Note that the values of v_0 are assumed to the same in inner and outer magnetosphere. In the Nottale's Bohr orbit model for the planetary orbits, outer planets and the 4 inner planets have different value of v_0: $v_0(outer) = v_0(inner)/5$. This would scale down the gravitational binding energy for outer planets by factor 1/25, which is reasonable. Scaling of v_0 in the case of Earth would increase cyclotron energy scale.

4.2.3 Critical summary

It must be admitted that I have not been able to develop the generalization of Nottale's hypothesis in a completely satisfactory form and it is best still to summarize the essentials. There is an excruciating uncertainty about the details related to the hypothesis.

(a) The hypothesis involves two parameters: $M_D \leq M$ and $\beta_0 = v_0/c$. The integer n labelling the Bohr orbit is an additional parameter. The critical question is whether M_D can really differ from M.

(b) Bohr orbit conditions expressing Newton's equation for circular orbit and angular momentum quantization in units of $\hbar_{gr}$ gives for the orbital radius T and velocity v the expressions in terms of the basic parameters.

$$\begin{aligned} R(n) &= n^2 \frac{GM_D}{\beta_0^2} = \frac{GM_D}{v^2} \quad , \\ v &= \frac{\beta_0}{n} \quad , \\ E &= \frac{mv_0^2}{8\pi^2 n^2} \quad . \end{aligned} \tag{4.1}$$

What is remarkable and perhaps strange looking is that velocity and binding energy are independent of the value of M_D. If one knows the orbital parameters, such as radius and period T one can

One can use various inputs in an attempt to fix the parameters of the model.

(a) In the case of the Sun, the radii and the velocities of the orbits of planets provide the information which allows to determine these parameters. $\beta_0(outer) = \beta_0(inner)/5$ relates the inner and outer planets. The value of n and $\beta_0(inner) \simeq 2^{-11}$ are determined by the planetary velocities. $M_D = M$ is implied by the known orbital radii.

(b) In the case of Earth there is no analog of planetary data available. The situation should look classical so that the values of n involved are large unlike in the case of Sun.

If the orbit of a stationary satellite is regarded as a Bohr orbit, one can get an estimate for n. In this case $v = v_0/n$ can be deduced from the period T and radius $R(n)$ of the orbit. For the stationary orbit, one has $R/R_E \simeq 6.62$. Newton's equation gives $GM_D/R = \beta^2$ so that $M_D = M$ must be true. If M_D depends on distance, $M_D \simeq M_E$ must hold true at distance about $6R_E$.

For $M_D = M$ and $\beta_0 = 2^{-11}$, $\beta = \beta_0/n$ gives $n \simeq 50$. Bohr orbit with Earth radius would have $n \simeq 19$. The reduction of M_D to $2 \times 10^{-4} M_E$ while keeping the radius of the Bohr orbit same, would require $n = 19 \to 1343$.

The above considerations are consistent with $M_D = M$. The hypothesis $M_D \simeq 2 \times 10^{-4} M_D$ deserves a critical discussion.

(a) The condition that the cyclotron frequencies in the endogenous magnetic field $B_{end} = .2$ Gauss postulated to explain the findings of Blackman and others correspond to $h_{eff} = h_{gr}$ for which the frequencies at EEG frequency range correspond to the energies in the energy range of biophotons. This gives $M_D \sim 2 \times 10^{-4} M_E$ and the proposed identification is as the mass of the inner-inner core of Earth. Its radius is roughly 5 per cent of the radius of Earth. The model for the fountain effect of super-fluidity is consistent with this estimate of M_D.

(b) If M_D really varies, the small masses m cannot couple to the entire mass of (say) Earth: this could be perhaps understood in the flux tube picture in the proposed way.

4.3 What about the reduction of G to G_D?

As noticed in the introduction, it is actually the parameter GM_D that appears in Bohr conditions. Could it be G is replaced with G_D and one has $M = M_D$? In TGD the value of G indeed comes out as a prediction. CP_2 length R defines the counterpart of Planck length l_P and Newton's constant G is predicted to be $G\hbar = R^2/n_1$, where $n_1 = \sim 10^7$.

One can also write $G = \frac{\hbar_{gr}\beta_0}{Mm}$. Could the value of n_1 increase so that the value of G is reduced to G_D?

(a) The condition is that also the new value divides $\hbar_{gr}$ or more precisely, the integer assignable to G in the decomposition of $\hbar_{gr}$ to a product of integers.

(b) n_1 has a number theoretic interpretation [K1] as a factor of the order of the Galois group assignable to $\hbar_{gr} = n_{gr} h_0$. The variation of n_1 is in principle possible and there is evidence for small variations of G perhaps assignable to that of n_1.

(c) The increase of n_1 by a factor about $10^4/2$ is in principle possible: one would have $G_D = 2 \times 10^{-4} G$. The new value of n_1 should also divide n_{gr}. This kind of reduction of G for the superfluid phase could also explain the fountain effect as a dramatic weakening of the Earth's gravitation at the gravitational flux tubes connecting Earth to superfluid.

(d) Why would not G be reduced for the ordinary matter? It seems that the superfluid-/dark particle property must change the coupling to gravity? The factorization of $\hbar_{gr} = G_D Mm/v_0$ would naturally correspond to the factorization of n_{gr} to a product of factors characterizing masses M, m and the flux tube?

If $G\hbar$ - when expressed using CP_2 length as unit - factorizes to product of integers assignable to M and m, then the integer associated with m would be reduced so that the reduction of G would characterize the dark particle with mass m.

Note that also Podkletnov effect [H3, H1] discussed from the TGD point of view in [L2] suggests a few per cent reduction of G.

(e) A geometric interpretation suggests itself [L38] . The basic factorization would correspond to a decomposition to $n_{gr} = n_1 n_2$. n_1 would correspond to the number of sheets of space-time surface as a covering of M^4 and n_2 as covering of CP_2: the interpretation as a quantum coherent flux tube bundle of n_2 tubes is suggestive. The values of n_2 would be larg and correspond to the factor Mm or Mm/v_0. n_1 would be relatively small and could correspond to G or its factorization to a produce of integers assignable to M and m. This makes sense since the coupling of m to gravitational flux tubes is assumed to be by touching.

To sum up, it seems that one should improve the physical understanding of the Galois group of extension, which in general is extension of extension of ... so that its dimension n is the product of dimensions of extensions involved. Do these dimensions correspond to effective Planck constants assignable to various interactions as suggested in [K1]?

4.4 The option based on variable value of β_0

The motivations for the model with a variable value of $\beta_0 = v_0/c$ have been already explained. In the sequel I will develop a model for the communications between dark matter phases with $h_{eff} = nh_0$ satisfying $h_{eff} = h_{gr}$. One can consider two options for the communications depending on whether the value of h_{eff} changes as (for instance) in the communications between dark and ordinary matter or whether it is preserved.

(a) If the value of h_{eff} can change, energy conservation for $E = h_{eff}f$ allows energy resonance whereas the frequency changes. The simplest option is that the dark photon transforms to say ordinary photon with the same amplitude

(b) If the value h_{eff} is preserved, one has both energy and frequency resonance. In the case of cyclotron radiation, the simultaneous occurrence of energy and frequency resonances poses strong conditions on the values of the magnetic fields, the values of charged particle masses, and the parameter β_0 at the ends of the communication line.

4.4.1 Conditions for frequency - and energy resonance

The condition that the frequency is the same at both ends implies for cyclotron frequencies $f_c = ZeB/2\pi m$ the condition

$$\frac{Z_1B_1}{m_1} = \frac{Z_2B_2}{m_2} \quad . \tag{4.2}$$

For $h_{eff} = h_{gr}$ the condition that the cyclotron energy $E_c = GMZeB/v_0$ at both ends is same implies

$$\frac{Z_1B_1}{v_{0,1}} = \frac{Z_2B_2}{v_{0,2}} \quad . \tag{4.3}$$

Together these conditions give

$$\frac{m_1}{m_2} = \frac{Z_1B_1}{Z_2B_2} = \frac{\beta_{0,1}}{\beta_{0,2}} \quad . \tag{4.4}$$

4. For instance, if the two particles are proton and electron, one obtains

$$\frac{\beta_{0,1}}{\beta_{0,2}} \simeq \frac{m_e}{m_p} \quad .$$

This ratio is is consistent with the values $\beta_{0,2} = 1$ and $\beta_{0,1} = 2^{-11}$ in the accuracy considered. Is this a mere accident?

4.4.2 Resonance conditions for communications from the Earth's surface to the magnetosphere?

The simplest option is that the interacting particles have the same values of mass and β_0 and magnetic fields are identical. This is achieved if the flux tubes have constant thickness. Whether this is the case is not clear.

However, the idea that the flux tube picture about magnetic fields is locally consistent with the Maxwellian view inspires the question whether also the magnetic field strength at the flux tubes of B_{end} behaves like $B_{end} \propto 1/r^3$ as B_E in dipole approximation behaves.

B_{end} is by flux conservation proportional to $1/S$, where S is the area of the flux tube. sOne would have $S \propto r^3$. The constancy of B_{end}/m would suggest $m \propto 1/r^3$. If the charged particles are ions characterized by the A/Z ratio.

This would suggest that the regions of tubes/sheets in frequency resonance are at distances

$$\frac{r}{r_0} = (\frac{Z}{Z_0})^{-1/3}(\frac{A_0}{A})^{-1/3}$$

for ions Z_0, A_0 at the surface of the Earth. The heaviest ions would be nearest to the surface of Earth. Energy resonance condition

$$\frac{B_{end}(r)}{\beta_{0,2}} = \frac{B_{end}(R_E)}{v_{0,1}}$$

would give the additional condition

$$\frac{\beta_{0,2}}{\beta_{0,1}} = (\frac{R_E}{r})^3 = \frac{Z}{Z_0} \times \frac{A_0}{A} \quad .$$

β_0 would be quantized and would decrease with the distance.

4.4.3 Magnetosphere as sensory canvas

TGD leads to a model of the "personal" magnetic body (MB) as being associated with the Earth's MS. Different regions of the body and brain would be mapped to regions of the MS, which would give rise to sensory representations at the personal MB [K11, K10]. Personal MB, which would have size scale of at least of the Earth's MS, would also control biological body.

1. An interesting finding relates to the values of the magnetic field $B_{end} \simeq 2B_E/5$ (perhaps identifiable as the monopole flux part of B_E) and the value of $B \sim 10$ nT in the magnetotail at the night-side of the Earth.

   One has $B/B_{end} \sim 2^{-11}$ so that for dark proton-dark electron communications between the Earth's surface and this region of outer MS the resonance conditions would be satisfied for $\beta_0 = x$ and $\beta_0 = 2^{-11}x$, where $x < 1$ not far from unity.

2. Could the parameter β_0 characterize particles and act as a tunable control parameter allowing to achieve energy resonance? Also the values of B are tunable by changing the thickness of the flux tubes as a kind of motor action of MB.

This idea can be applied to the h_{eff} preserving communications between biological body and the MS of the Earth.

1. The quantum coherence condition suggests that the communications are optimal when the wavelength of dark photon is larger than the distance considered: $\lambda > r$ or equivalently the frequency satisfies $f \leq c/r$ (one has $c = 1$ in the units used). If the structure of the MS has distances from the Earth's surface below r_{max} then the frequencies $f \leq 1/r_{max}$ are optimal.

2. Given the distance r_{max} and assuming $B = B_{end}$ at the surface of Earth, one obtains for the cyclotron frequencies the condition

   $$f_c = \frac{ZeB_{end}}{2\pi m} \leq \frac{1}{r_{max}} \quad .$$

   For instance, EEG frequency 10 Hz corresponds to 3×10^7 m. The cyclotron frequency of DNA sequence does not depend on its length and composition since DNA has constant charge per unit length. One has $f_c \simeq 1$ Hz so that the corresponding distance is $r = 3 \times 10^8$ m, that is $r = 46.9R_E$.

   Remark: B_{end} probably has a spectrum. Music experiences relies on frequency scale and if the audible frequencies correspond to cyclotron frequencies then eB_{end}/m is variable. This suggests that the spectrum of B_{end} covers at least the range of the audible frequencies spanning roughly 10 octaves [K17].

5 Can TGD predict the value of Newton's constant?: the view two years later

Newton's constant G cannot be a fundamental constant in TGD framework . G has dimensions of length squared divided by Planck constant and CP_2 length R is the only fundamental length in TGD Universe. The analog of Newton's constant $G = R^2/\hbar$ is too larger by factor of order $10^7 - 10^8$: the previous estimate gives for this factor the value $2^{24} = 16,777,216 = 1.6777216 \times 10^7$.

The first guess was that one must modify the formula by replacing $\hbar$ with h_{eff} with $h_{eff} = nh_0$, $h = 6h_0$: $G = R^2/\hbar_{eff}$ (see [L5, L21, L41]).

n has however has arbitrarily values and the proposal cannot be correct as such if one accepts the notion of gravitational Planck constant $\hbar_{gr} = GMm/v_0 = h_{eff} = nh_0$: here M and m are masses of systems having gravitational interaction and $v_0 < c$ is velocity parameter having value $v_0/c \simeq 2^{-11}$ for inner planets [E6] [K20, K13, K14]. h_{gr} is assigned with the flux tubes mediating gravitational interaction.

One can assign also to other interactions corresponding effective Planck constants - for instance, $h_{em} = Z_1 Z_2 e^2/\beta_0$, $\beta = v_0/c < 1$ to electromagnetic interactions. The general idea is that when the value of coupling strength $Q_1 Q_2 g^2/\hbar$ for a two particle system becomes so large that perturbation theory fails, Planck constant is replaced with h_{eff} and perturbation theory works again. Topologically this means a phase transition replacing space-time sheets with their n-fold coverings.

5.1 Development of ideas

5.1.1 More general formula for G

The more general proposal is that h_{eff} in the formula for G must be replaced with $h_{gr,1} = n_{gr} h_0$, where n_{gr} is closely related to the $n = h_{eff}/h_0$ but not equal to it. The estimate $G\hbar/R^2 \simeq 1.6 \times 107$ and $\hbar = 6\hbar_0$ gives the estimate $n_{gr} = 6 \times 2^{24} \simeq 1.00663296 \times 10^8$.

To make the continuation easier, it is good to express the idea in more detail.

1. CP_2 "radius" R identified in terms of geodesic length $l = 2\pi R$ is the fundamental geometrically realized unit of length measurement, and takes the role of Planck length $l_P^2 = G\hbar$ having only dimensional analytic justification. G is now the prediction and the first guess is $G = R^2/\hbar_{gr,1}$, where $\hbar_{gr,1} = n_{gr} \times \hbar_0$ is effective Planck constant with n_{gr} identified as dimension of "gravitational" extension of rationals.

   $n = h_eff/h_0$ is the number of sheets of covering of space-time surface transformed to each other by Galois group. Since l_P/R is in the range $10^{-7} - 10^{-8}$, one must have $\hbar_{gr,1}/\hbar$ in the range $10^7 - 10^8$.

2. In principle $n_{gr}/6$ could have values $10^{-7} - 10^{-8}$ times smaller than the value associated with G. If so, G could be up to factor $10^7 - 10^8$ times larger than the standard value $G = G_N$. The downwards fluctuations of $\hbar_{eff}$ strengthen the gravitational attraction. One cannot exclude even large fluctuations of G.

5.1.2 The first attempt to identify n_{gr} fails

The motivation for this article came from an attempt to understand the value of gravitational constant G as a prediction of TGD - I have already earlier developed a model in which gravitational constant is predicted in terms of CP_2 radius R and a number related to effective Planck constant $h_{eff} = nh_0$.

1. The first proposal was that one can write $h_{eff}/h_0 = n$ as $n = n_1 \times n_2$, where n_1 is the number of sheets of space-time surface as a covering M^4 (space-time points with same CP_2 coordinates) and n_2 is the number of sheets as covering CP_2 (space-time points with same M^4 coordinates). There would be n_1 different space-time sheets for given M^4 projection - this corresponds to the idea about many-sheeted space-time. There would be n_2 different regions of space-time for given region of CP_2 projection. One can imagine n_2 parallel flux tubes in M^4 forming a coherent structure. This intuitive picture could but need not survive in more precise formulation.

2. The improved formula would be $G = R^2/n_{gr}\hbar_0$, where one as either *a)*: $n_{gr} = n_1$ or *b)*: $n_{gr} = n_2$. Which option - if either of them - is the correct one? Note that the option $n_{gr} = n$ is not possible since b can have huge values and G would approach to zero for dark matter in long length scales: with the recent understanding of physics this does not look plausible.

The limit $n_{gr} < n_{nmax} \sim 10^8$ means a bound on the number of space-time sheets over M^4 or CP_2.

1. For option *a)* with $n_{gr} = n_1 < n_{max} \sim 10^8$ one can imagine that the Galois group corresponds to a discrete finite sub-group of $SU(3)$, analogous to the isometry groups of Platonic solids. In the case of $SO(3)$ the order of this group is bounded to the order 60 of isosahedral group unless the group is Abelian. The largest discrete sub-group of $SU(3)$ analogous to icosahedral group has order 1080 and is too small by several orders of magnitude.

   Remark: The number parallel flux tubes could be arbitrarily large for tis option - a possible interpretation would be that gravitational quantum coherence is true in very long length scales.

2. For option *b)* with $n_{gr} = n_2 < n_{max}$ would state that the number of parallel flux tubes forming a coherent structure is bounded. The number of space-time sheets over M^4 could be arbitrarily large. The only natural symmetry group for M^4 is discrete sub-group of $SO(3)$. For the icosahedral group the order is 60 and quite too small.

Both options fail.

5.1.3 A modified formula for G

The failure forces to consider a more general formula for G. The outcome is the following argument.

1. TGD predicts a hierarchy of effective Planck constants $h_{eff}/h_0 = n$, where n is the order of Galois group of Galois extension defining extension of rationals [L14, L15] [**?**, K14]. Dimension n of extension factorizes to a product $n = n_1 n_2 ...$ for extension E_1 of extension E_2 of .... rationals. $M^8 - H$ correspondence allows to associate the Galois group with an irreducible polynomial characterizing space-time surface as an algebraic surface in M^8. The gradual increase of extension by forming a functional composite of a new polynomial with the already existing one ($P \to P_{new} \circ P$) would be analogous to the evolution of genome: earlier extensions would be analogous to conserved genes.

2. The proposal modifying the earlier proposal is $G = R^2/n_{gr}\hbar_0$, where n_{gr} is the order of Galois group G_{gr} "at the bottom" of the hierarchy of extensions, and one has $\hbar = 6h_0$. One would have $n = n_1 n_2 ... n_{gr}$. G_{gr} "at the bottom" is proposed to represent number theoretically geometric information about the embedding space by providing a discretization for the product of maximal finite discrete sub-group of isometries and tangent space rotations of embedding space.

3. By $M^8 - H$ duality these sub-groups should be identical for H and M^8. The prediction is that maximal G_{gr} is product of icosahedral group I with 3 copies of coverings $\bar{I}$. Rather remarkably, the prediction for G is correct if one assumes that the value of R is what p-adic mass calculation for electron mass gives.

Since the hierarchy of Planck constants relates to number theoretical physics proposed to describe the correlates of cognition, the connection with cognition strongly suggests itself. Icosahedral and tetrahedral geometries occur also in the TGD based model of genetic code in terms of bioharmony [L1], which suggests that genetic code represents geometric information about embedding space symmetries. These connections are discussed in detail.

5.2 A formula for G in terms of order of gravitational Galois group and implications

In the sequel the formula $G = R^2/n_{gr}\hbar_0$ will be deduced from number theoretical vision based on adelic physics [L14, L15] and $M^8 - H$ duality [L10, L11, L12, L33]. The prediction allows variation of G - G is indeed known to vary more than expected. These "small" variations and also possible large variations are discussed. The successful prediction forces to consider seriously the connections between quantum gravitation, cognition, and quantum biology, in particular genetic code.

5.2.1 An improved attempt to identify n_{gr}

The original proposal for a formula of $G = R^2/n_{gr}\hbar_0$ failed and one must try something more general.

1. The Galois group of Galois extension has a decomposition in terms of a hierarchy of normal sub-groups. G can be represented as product of maximal normal sub-group H and group G/H. H in turn has similar decomposition and the process can be continued to get a hierarchical decomposition. This leads to a concrete model for "small" state function reduction (SSFR) as a cascade of cognitive measurements. Some special normal sub-group in the hierarchy relevant for gravitation is a good candidate for "gravitational" Galois group G_{gr}, whose order is n_{gr}.

   An attractive assumption is that the Galois group assignable to gravitational interactions is fundamental in the sense that it corresponds to the lowest step of the Galois ladder. The vision about evolution inspired by M^8-H duality is as an increasing hierarchy of polynomials P with rational coefficients defining space-time surfaces as algebraic surfaces in complexified M^8: their real projections would define 4-D space-time surfaces mapped to $H = M^4 \times CP_2$ by $M^8 - H$ duality [L10, L11, L12].

   Polynomials P would be functional composites as a generalization of abstraction process as statements about statements and evolution would proceed as sequence of abstraction steps $P \to P_{new} \circ P$. This step preserve the roots of P if the polynomials involved vanish at origin: $P(0) = 0$. Besides Galois groups the roots associated with earlier steps would be evolutionary invariants analogous to conserved genes. If one has decomposition $P = P_1 \circ P_2 ... \circ P_{gr}$, one could understand why why n_{gr} is almost universal constant.

2. Gravitation relates to space-time geometry and a good guess is that G_{gr} provides a representation for a discrete finite sub-group of the isometry group of embedding space and perhaps also for the sub-group $SO(3) \subset SO(3,1)$ acting in $E^3 \subset M^4$ or its lift to $SU(2)$. Octonionic structure in M^8 indeed selects unique rest system and even the spatial origin of the linear coordinate system is fixed. This would reduce the attempt to identify n_{gr} to a study of finite discrete sub-groups of embedding space isometries and spin covering of its tribein rotation group.

   It must be made clear that G_{gr} would be associated with the space-time sheets mediating gravitational interactions: this would include gravitational flux tubes with $\hbar_{gr} = GMm/v_0$. For flux tubes mediating - say - electromagnetic interaction the counterpart of G_{gr} could be much smaller, it would however include the group $Z_2 \times Z_3$, which is center for $SU(2) \times SU(3)$ predicting $h = 6h_0$ suggested by some empirical findings [L5, L21, L41].

3. By $M^8 - H$ duality one must consider the isometry groups and 3-D tangent space-groups of both M^8 and H to see whether n_{gr} could find a natural identification. $M^8 - H$ duality requires that the gravitational sub-group is same for M^8 and H options.

   The group $SO(3) \times U(2)$ is shared by $SO(3) \times SU(3)$ for H and $SO(3) \times SO(4)$. Tangent space group of $E^3 \subset M^4$ is $SU(2)$ and tangent space group of CP_2 is $U(2)$ in the two cases and if only maximally non-Abelian groups are accepted $U(2)$ effectively reduces to $SU(2)$, which can however correspond to a non-trivial sub-group of $U(2)$. This would mean that the maximal finite discrete sub-group of isometries and vielbein groups is direct product of 4 groups, which are icosahedral groups I or their coverings $\overline{I}$.

The orders of icosahedral group I without reflection *resp.* its covering $\overline{I}$ is 60 *resp.* 120. $SU(2)$ for the tangent space groups is natural hypothesis since one has also fermions. For $I \times \overline{I}^3$ one would have $n_{gr} = 8 \times 6^4 \times 10^4 \simeq 32^{11} \times 15^4 = 1.0368 \times 10^8$. This is to be compared with the rough estimate $n_{gr} = 6 \times 2^{24} \simeq 1.00663296 \times 10^8$. The proposal works amazingly well!

4. Also other Platonic groups assignable to Platonic solids (tetrahedron, cube and octahedron, icosahedron and dodecahedron) are in principle possible: actually all discrete and finite subgroups of $SU(2)$ can be considered. The non-Platonic groups however act on plane polygons, and might be more naturally assignable other than gravitational interactions. They are also associated with Mac-Kay correspondence [K23] assigning to these finite groups ADE Lie groups/Kac-Moody algebras. This hierarchy is also associated with inclusions of hyperfinite factors of type II_1 (HFFs) proposed in TGD framework to provide a representation for finite measurement resolution [K28, K7].

5.2.2 Could Newton's constant vary and what about formulas for other coupling strengths?

The proposed formula for G forces to consider the possibility of large variations of G due to the variation of n_{gr} as the order of gravitational Galois group G_{gr}. This group is fixed by $M^8 - H$ duality to be a product of finite discrete sub-groups of $SO(3)$ with 3 discrete sub-groups of $SU(2)$. By loosening the conditions one can however think also the possibility of other choices

1. The allowance of only Platonic solids would make possible to understand possible large increases of G but not its reduction. What is interesting is that the increase of G implies increase of gravitational Compton length $\Lambda_{gr} = G(M+m)/v_0$ unless G/v_0 is constant.

2. If one accepts also the non-Platonian finite sub-groups of $SU(2)$ with representations are realized as 2-D polygons, the range of values of G is much larger and both large and small variations of G from the preferred value become possible as variations of n_{gr}.

3. If one wants to explain the reported small but theoretically too large variations of G allowing only Platonic solids, one must allow superpositions of space-time surfaces with different values of n_{gr}. In general $\langle n_{gr} \rangle$ would be smaller than the maximal value and $\langle G \rangle$ would increase. Large variations decreasing G cannot be explained in terms of Platonic solids or their superpositions.

4. If one gives up $M^8 - H$ duality larger variations of G downwards become possible. For instance, $\overline{I}$ in the case of $SU(3)$ isometries could be replaced with $\Sigma(1080)$ with 1080 elements (`http://tinyurl.com/uq3nxko`). This would reduce G by factor $1080/120 = 9$. More generally, in $SU(3)$ there are following analogs of Platonic groups labelled as $\Sigma(n)$, $n \in \{60, 168, 36 \times 3, 72 \times 3, 21 \times 3, 72 \times 3 = 216, 216 \times 3 = 648, 360 \times 3 = 1080\}$. Also the semi-direct products $\Sigma(60) \times Z_3$ and $\Sigma(168) \times Z_3$ belong to the list.

The counterpart of ADE hierarchy for $SU(3)$ is obvious interest from the point of view of color interactions if one allows the breaking of $M8-H$ duality. There is an article by Ludl in arXiv [B2] (`http://tinyurl.com/uq3nxko`) about the finite discrete sub-groups of $SU(3)$. Table 1 of the article provides a summary of the discrete sub-groups.

1. There are 3 series parameterized by several integers with no general formula for the order. The are however infinite series of groups which belong to these series and have unbounded order. These groups are semi-direct products, which makes their representability as Galois groups of Galois extensions possible.

   Could these groups be associated with the flux tubes mediating color interactions? Could colour coupling strength be expressible as $\alpha_s = g_s^2/4\pi\hbar_s$, where $\hbar_s = n_s\hbar_0$? Could the value of g_s^2 be equal to the square g_K^2 of Kähler coupling defining fundamental constant. Could similar expression hold true also for electroweak coupling strengths. Could the breaking of gauge and gravitational symmetries be coded by different values of n_s,$n_{SU(2)_{ew}}$, $n_{U(1)}$, and n_{gr}.

2. There are also following exceptional groups analogous to Platonic groups for $SU(3)$ and labelled as $\Sigma(n)$, $n \in \{60, 168, 36\times 3, 72\times 3, 21\times 3, 72\times 3 = 216, 216\times 3 = 648, 360\times 3 = 1080\}$. Also the semi-direct products $\Sigma(60) \times Z_3$ and $\Sigma(168) \times Z_3$ belong to the list. The largest order for this series is 1080. The smallest order is 60 and corresponds to icosahedral group.

The discrete sub-groups of $SO(4)$ are interesting in M^8 picture and could contain also semi-direct products as sub-groups for products of sub-groups of $SO(3)$ and $SU(2)$. These sub-groups are listed in the appendix of the article by de Medeiros and Figueroa-O'Farrill (`http://tinyurl.com/tyagn3c`).

5.2.3 What do experiments say?

What do experiments say? Various experiments have been already discussed.

1. Several experiments suggests small variations of G, which are however too large theoretically. There are experiments in millimeter scales and also Podkletnov's experiment [H3, H2] [L2].

2. Could the fountain effect of super-fluidity be understood as a large reduction the value of G. It seems that a more elegant explanation is in terms of macroscopic quantum coherence due to the large value of $h_{gr} = GMm/v_0$ for space-time sheets mediating gravitation in the case of super-fluid [**?**].

3. The findings reported by Martin Grusenick [K21] - *if true* - would suggests a huge increase of G by a factor of order 10^5 if the increase of spatial lengths in the direction of the Earth's magnetic field causes the effect. The variation is too large to have an explanation allowing only Platonic solids alone. The effect could be due to the contraction of the measurement apparatus under its own weight.

   Perhaps a more elegant explanation for Grusenick's claim would be in terms of warping of space-time surface possible even in absence of gravitational field predicted by TGD. Warping means that the space-time surface has metric isometric with Minkowski metric but when the M^4 coordinates of $M^4 \subset M^4 \times CP_2$ are used, there is a scaling of the metric in various directions since CP_2 projection of the embedding is not a point but geodesic circle. This would modify the propagation velocity in radial direction.

4. One can also ask whether the unexpected mass for the blackhole candidates observed by LIGO could be due to anomalously large value of G. In TGD framework the view about blackhole like entities is much more detailed than in GRT and one could understand them also without variation of G.

Since consciousness, cognition, and gravitation are closely related in TGD Universe, one cannot avoid association with the claims made by meditators about levitation. Could the experience about levitation mean a genuine levitation of dark matter at the level of magnetic body (MB), which corresponds to a higher level cognitive consciousness and naturally gravitational consciousness by huge values of $\hbar_{gr}$.

1. Could G be reduced producing anti-gravitational effect at MB? If one allows only $M^8 - H$ duality and Platonic solids G is smallest possible and cannot be reduced. Allowing also polygons would allow arbitrary small values of G. This option does not look however plausible since one can argue that the experience would reduce from 3-D for Platonic solids to 2-D for regular polygons.

2. Perhaps a more elegant explanation is that levitation experiences and out-of-body experiences [K22] (OBEs, which I have had also myself), are due to the delocalization of particles of "personal" MB due to the large value of h_{gr}. One could perhaps say that the active flux tubes of MB correspond to those mediating gravitational interaction and having $h_{gr} = GMm/v_0$. Ironically, gravitational consciousness would be experience of no having no weight.

5.2.4 A connection gravitation and genetic code?

A deep connection between gravitation and genetic code suggests itself.

1. TGD suggests at least two fundamental representations of genetic code besides the usual chemical representation. The first representation is terms of dark nuclei consisting of sequences dark proton triplets representing codons [L3, L17]. Both DNA, RNA, tRNA and amino-acids have analogs as dark proton sequences. Second representation is in terms of dark photon triplets defining what I call bio-harmony [L1]. Basic objection against emission of 3-dark photons simultaneously is that the process is extremely probable. If one has however Galois confinement in the sense that only Galois singlets appear as asymptotic states, the assumption that dark photons are Z_3 triplets allows only the emission of triplets [L41].

2. What is fascinating that both icosahedral and tetrahedral groups appear in the model for the genetic code in terms of bio-harmony [L1, L27, L30]. Could genes and associated molecules DNA, RNA, tRNA, and amino-acids code for information about the geometry of embedding space in some sense? DNA codons correspond to 20 triangular faces of icosahedron (3 Hamiltonian cycles are used obtain 202+20+20=60 codons) and 4 triangular faces of tetrahedron to get the remaining 4 codons. By icosahedral-dodecahedral duality gene as a sequence of these faces defines a path at dodecahedron - two subsequent codon of gene would not however map to nearest points at dodecahedron. What could this mean if anything?

3. Genes code for information and therefore could relate to cognition, and the proposed representations of genetic code would mean that genes emerge already at the fundamental level: chemical representation would be only mimicry of the dark nuclear code at higher, chemical level. The hierarchy of Planck constants relates also directly to information and h_{eff} can be seen as a kind of "IQ".

   The dependence of G on n_{gr} suggest that also gravitation relates to cognition. This would not be surprising since the long-ranged non-screened character of gravitation could make possible quantum coherence in astrophysical scales: the value $h_{eff}/h_0 = n = h_{gr}/h_0$ is indeed a direct measure of the evolutionary level.

   The connection with cognition could also explain why ancient mathematicians managed to discover the mathematical structures encountered two millenia later in theories trying to unify fundamental interactions.

5.2.5 Could Newton's constant relate to cognition?

After having discovered the above argument fixing n_{gr} from M^-H duality, I could have written conclusions of the paper. The emphasis however shifted to TGD based view about evolution and cognition and its connection with gravitation. h_{eff} indeed closely relates to an evolutionary hierarchy of cognition via the idea that gravitational/geometric part of Galois group is fundamental and "at the bottom" of the hierarchy of Galois extensions of rationals. Extensions of rationals would define cognitive representations representing discretizations of spaces of various dimensions as subsets of reals or complex numbers, and also allow to represent discrete sub-groups approximating continuous groups as Galois groups.

The most fundamental physics related groups to be approximated as Galois groups would relate to the isometries and vielbein rotations of embedding space. The maximally compact sub-group would be in question both cases. The important point would be that these groups would act on extension of rationals providing cognitive representation as subset of reals/complex numbers rather than in embedding space. This kind of representation would be analogous to a linguistic, linear representation of geometric object as opposed to concrete geometric representation in embedding space.

5.3 Could gravitation and geometric cognition relate?

It has been already demonstrated how one can predict the value G correctly as in TGD framework. The emphasis of this section is on geometric cognition and the possibility that the value of G directly reflects this connection.

5.3.1 Hierarchy of effective Planck constants and Galois extensions of rationals

In adelic vision [L14, L15, L10, L11, L11] about TGD $n = h_{eff}/h_0$ corresponds to the dimension of extension of rationals characterizing space-time surface. n is also the order of Galois group of extension for Galois extensions. Recall that Galois extension has the nice property that the order of Galois group equals to the dimension of the extension. Galois extension can be regarded as extension of extension of....rationals an there is a hierarchy of Galois group such that the included sub-groups are normal sub-groups. One can express n as a product $n = n_1 n_2$.. of the dimensions of these extensions.

This leads to the vision about the reduction of evolution to a hierarchy of Galois extensions such that evolution means increase of the extension and therefore number theoretical complexity and of h_{eff} meaning increase of quantum coherence scale.

If the extensions tend to emerge as further extensions preserving the earlier extensions - as is natural to think -, the extension "at the bottom" of the hierarchy of extensions is rather stable. Since the geometric cognitive consciousness can be argued to be fundamental, the dimension of Galois group corresponds to n_{gr} in $n = n_1 n_2 .... n_{gr} = m \times n_{gr}$. n_{gr} would be rather stable factor of n.

n_{gr} would be analogous to the conserved genes of primary life form from which evolution started. The change of genome at this level would induce dramatic changes making the survival of the new life form implausible. This alone would not predict unique value for n_{gr} but only that its value is dynamically rather stable. One must of course understand why this particular value of n_{gr} would be selected. What distinguishes this extension from a general extension? The groups in question allow infinite number of finite discrete sub-groups but $M^8 - H$ duality would select highly unique sub-groups as common to both. Only groups, which are products of 4 isometry groups of Platonic solids or there double coverings and maximal order for the group minimizing G would leave only the icosahedral group I and its coverings into consideration.

5.3.2 $M^8 - H$ duality and representation of space-time surfaces in M^8 as algebraic surfaces assignable to polynomials with rational coefficients

$M^8 - H$ duality [L33] provides a concrete realization of the number theoretic vision in terms of space-time surfaces, and also allows to realize the view about number theoretical evolution in terms of a hierarchy of polynomials obtained by functional composition of polynomials.

The articles [L10, L11, L12] contain a detailed description of $M^8 - H$ duality. The article [L40] described a possible connection with chaos theory and Mandelbrot/Julia fractals based on the possibility that time evolution by "small" state function reductions (SSFRs) correspond in good approximation iteration of polynomial. The article [L43] describes a model of SSFR as a cognitive measurement identified as a reduction cascade in the group algebra of Galois group having a decomposition in terms of normal sub-groups.

Basic vision

Consider first what TGD space-time is.

1. In TGD framework space-times can be regarded 4-surfaces in $H = M^4 \times CP_2$ or in complexification of octonionic M^8. Linear Minkowski coordinates or Robertson-Walker coordinates for light-cone (used in TGD based cosmology) provide highly unique coordinate choice and this problem disappears.

2. The solutions of field equations are preferred extremals satisfying extremely powerful additional conditions giving rise to a huge generalization of the ordinary 2-D conformal symmetry to 4-D context. In fact, twistor twist of TGD predicts that one has minimal surfaces, which are also extremals of 4-D Kähler action apart from 2-D singularities identifiable as string world sheets and partonic 2-surfaces having a number theoretical interpretation. The huge symmetries act as maximal isometry group of "world of classical worlds" (WCW) consisting of preferred extremals connecting pair of 3-surfaces, whose members are located at boundaries of causal diamond (CD). These symmetries strongly suggest that TGD represents completely integrable system and thus non-chaotic and diametrical opposite of a chaotic system. Therefore the chaos - if present - would be something different.

$M^8 - H$ duality suggests an analogous picture at the level of M^8. $M^8 - H$ duality in itse most restrictive form states that space-time surfaces are characterized by "roots" of rational polynomials extended to complexified octonionic ones by replacing the real coordinate by octonionic coordinate o [L10, L11, L12].

1. One can define the imaginary and real parts $IM(P)$ and $RE(P)$ of $P(o)$ in octonionic sense by using the decomposition of octonions $o = q_1 + I_4 q_2$ to two quaternions so that $IM(P)$ and $RE(P)$ are quaternion valued. For 4-D space-time surfaces one has either $IM(P) = 0$ or $RE(P) = 0$ in the generic case. The curve defined by the vanishing of imaginary or real part of complex function serves as the analog.

2. If the condition $P(0) = 0$ is satisfied, the boundary of δM^8_+ of M^8 light-cone is special. By the light-likeness of δM^8_+ points the polynomial $P(o)$ at δM^8_+ reduces to ordinary real polynomial $P(r)$ of the radial M^4 coordinate r identifiable as linear M^4 time coordinate t: $r = t$.

   Octonionic roots $P(o) = 0$ at M^8 light-cone reduce to roots $t = r_n$ of the real polynomial $P(r)$ and give rise to 6-D exceptional solutions with $IM(P) = RE(P) = 0$ vanish. The solutions are located to δM^8_+ and have topology of 6-sphere S^6 having 3-balls B^3 with $t = r_n$ as of M^4_+ projections. The "fiber" at point of B^3 with radial M^4 coordinate $r_M \leq r_n$ is 3-sphere $S^3 \subset E^4 \subset M^8 = M^4 \times E^4$ contracting to point at the δM^4_+.

   These 6-D objects are analogous to 5-branes in string theory and define "special moments in the life of self". At these surfaces the 4-D "roots" for $IM(P)$ or $RE(P)$ intersect and intersection is 2-D partonic surface having interpretation as a generalization of vertex for particles generalized to 3-D surfaces (instead of strings). In string theory string world sheets have boundaries at branes. Strings are replaced with space-time surfaces and branes with "special moments in the life of self".

   Quite generally, one can consider gluing 4-D "roots" for different polynomials P_1 and P_2 at surface $t = r_n$ when r_n is common root. For instance, P and its iterates $P^{\circ N}$ having r_n and the lower inverse iterates as common roots can be glued in this manner.

3. It is possible complexify M^8 and thus also r. Complexification is natural since the roots of P are in general complex. Also 4- space-time surface is complexified to 8-D surface and real space-time surface can be identified as its real projection.

To sum up, space-time surfaces would be coded a polynomial with rational or at most algebraic coefficients. Essentially the discrete data provided by the roots r_n of P would dictate the space-time surface so that one would have extremely powerful form of holography.

Should one allow also transcendental extensions?

One can consider generalizations of the simplest picture.

1. One can also consider a generalization of polynomials to general analytic functions F of octonions obtained as octonionic continuation of a real function with rational Taylor coefficients: the identification of space-time surfaces as "roots" of $IM(F)$ or $RE(F)$ makes sense.

2. What is intriguing that for space-time surfaces for which $IM(F_1) = 0$ and $IM(F_2) = 0$, one has $IM(F_1F_2) = RE(F_1)IM(F_2) + IM(F_1)RE(F_2) = 0$. One can multiply space-time surfaces by multiplying the polynomials. Multiplication is possible also when one has $RE(F_1) = 0$ and $IM(F_2) = 0$ or $RE(F_2) = 0$ or $IM(F_1) = 0$ since one has $RE(F_1F_2) = RE(F_1)RE(F_2) - IM(F_1)IM(F_2) = 0$.

   For $IM(F) = 0$ type space-time surfaces one can even define polynomials analytic functions of the space-time surface with rational Taylor coefficients. One could speak of functions having space-time surface as argument, space-time surface itself would behave like number.

3. One can also form functional composites $P \circ Q$ (also for analytic functions with complex coefficients). Since $P \circ Q$ at $IM(Q) = 0$ surface is quaternionic, its image by P is quaternionic and satisfies $IM(P \circ Q) = 0$ so that one obtains a new solution. One can iterate space-time surfaces defined by $Im(P) = 0$ condition by iterating these polynomials to give

$P, P^{circ2}, ..., P^{\circ N}...$ From $IM(P) = 0$ solutions one obtains a solutions with $RE(Q) = 0$ by multiplying the M^8 coordinates with I_4 appearing in $o = q_1 + I_4 q_2$.

The $Im(P) = 0$ solutions can be iterated to give $P \to P \circ P \to ..$, which suggests that the sequence of SSFRs could at least approximately correspond to the dynamics of iterations and generalizations of Mandelbrot and Julia sets and other complex fractals and also their space-time counterparts. Chaos (or rather, complexity theory) including also these fractals could be naturally part of TGD!

5.3.3 Evolution of cognition

Polynomials in M^8 obtained as continuation of real polynomials with rational (or perhaps even algebraic) coefficients and vanishing at origin define a concrete representation for the extensions of rationals. There is infinite number of polynomials realizing the same extension. The interpretation is as an evolutionary hierarchy.

Since the number of extensions larger than given extension is larger than those smaller than it, the sequence of BSFRs changing the extension leads unavoidably to evolution as a statistical increase of the dimension of extension. The functional composition of polynomials which vanish at origin gives rise to evolutionary hierarchies for which the number theoretical complexity increases as one climbs up in the hierarchy. Extensions in these hierarchies are analogous to conserved genes if the replacement of extension F in BSFR can only extend F to larger extension E. This might be true in statistical sense.

Extensions could increase statistically also in SSFRs. In [L40] I considered the possibility that the sequence of SSFRs could correspond in reasonable approximation to an iteration of polynomial P. This would give direct connection with the Mandelbrot and Julia fractals.

The basic question is whether the number theoretical vision based on M^8 and adelic physics could be seen as exact dual of the geometric vision based on $H = M^4 \times CP_2$ and the notion of "WCW" (WCW) or does number theoretical view describe cognitive representations as approximate mimicry of actual physics so that the duality would be many-to-1.

The latter option seems to more plausible. Evolution leads to an improved representations but 1-1 correspondence is not reached even at the level of algebraic numbers allowing cognitive representations dense at space-time surface, but might be reached by accepting transcendental extensions replacing polynomials with analytic functions with rational (or even algebraic) coefficients to guarantee the continuation to p-adic number fields. One argument in favor of transcendentals is that exponential functions and trigonometric functions should be possible. Exponential functions would force e which however defines finite-D extension of p-adic numbers. The roots of trigonometric functions would bring in π and is powers.

General ideas about cognition and cognitive representations

Consider first cognitive representations at space-time level.

1. Cognitive representations at the level space-time surfaces would be provided by the points of space-time surface with embedding space coordinates in extension of rationals considered. One the coordinates of embedding space are fixed, these discretization are unique. The selection of coordinates is in the octonionic case highly unique. Only time translation in the rest system defined by the linear octonion coordinates is allowed. Also in case H the coordinates are unique apart from color rotations. Also vielbein/spin rotation group of 3-surface could have representation as a Galois group.

2. Galois group would act on the cognitive representation at space-time level and in general would not leave it invariant so that one would obtain new space-time surface. The wave functions in the space of space-time surfaces would correspond to wave functions in the space of cognitive representations which would correspond to elements of Galois group or factor space if sub-group of Galois group leaves the representation invariant. Wave functions would be elements of the group algebra of Galois group with possible conditions corresponding of invariance with respect to sub-group restricting the function to coset space effectively. This picture leads to a vision about "small" state function reductions (SSFRs) as cascades of measurements leading to a tensor product of states in the hierarchy of normal sub-groups of Galois group [L43]. The interpretation would be as cognitive measurements.

3. What about fermions? Fermionic Fock states have in TGD framework interpretation in terms of quantum variant Boolean algebra realized in terms of multi-qubits. One can say that the spinor structure of space is kind of square root of metric and describes correlates of logic [L42]. This would apply even at the level of WCW.

   What could finite measurement and cognitive resolution for fermions mean? The natural hypothesis is that the group algebras of Galois groups generated by wave functions in Galois group and having dimension n equal that for extension of rationals describe bosonic degrees of freedom and that fermionic state correspond to the spinors in this algebra- possible restrictions come from chirality restrictions. The dimension of the spinor space would be at most 2^n.

Cognitive representations at space-time level would be rather concrete. But is it possible to realize mathematical imagination, is it possible to imagine higher-D spaces?

1. Cognitive representations would indeed occur already at the level of number system. The extension of rationals can be regarded as n-D space over rationals instead of reals and would be mapped to a dense subset of real variant of n-D space. One can say that subset of real (or complex) numbers represents cognitively the higher-D space. The Galois group would represent discretization for the symmetries of these n-D space and from this one can say something about the possible isometry group of the corresponding real or complex space.

   This ability to imagine real and complex spaces of arbitrary dimension and might be fundamental aspect of mathematical consciousness.

2. If one takes seriously the idea about the connection with Newton's constant G, one can ask whether the evolution of the mathematical cognition proceeded via the gradual increase of the order of G_{gr} and meant gradual reduction of G in rather dramatic steps if only Platonic groups are allowed.

   Remark: Nottale's proposal for h_{gr} implies that gravitational Compton length for two particle system is $G(M+m)/v_0$ and increase with G since h_{gr} increases. If the velocity parameter v_0 and G do not correlate, larger value of G and therefore smaller value of n_{gr} and lower level of space-time consciousness would mean longer gravitational Compton length as a measure for quantum coherence and higher level of consciousness. This looks somewhat strange. Should one conclude that v_0 and G correlate: for instance, could G/v_0 be independent of G_{gr}?

How could mathematical physics as correlation between cognitive/imagined and sensory worlds have emerged?

1. Somehow the idea that we live in Euclidian 3-space emerged and later emerged special relativity, general relativity and its followers. It seems essential that the cognitive representations at the level of number field found counterparts at the level of sensory world represented as 3-space and eventually space-time and embedding space.

   Quaternions and octonions are naturally assignable to M^8, M^4 and H. Quaternions have $SO(3)$ as the analog of Galois group with concrete geometric interpretation. The discovery would be that this group acts on the object of sensory world. Could it be that these two equivalent choices of embedding space are the only ones for which this consciousness about this sensory-cognitive correspondence can evolve? The essential point would be that the symmetry groups of physics would be sub-groups of automorphism groups for octonions and quaternions.

   Remark: The extension allowing discrete sub-group of $SO(3)$ as Galois group must be distinguished from much smaller extension needed to represent this sub-group as 3×3 orthogonal matrices.

2. Could the emergence of the idea of Platonic solids - say in mathematics of ancient Greece - correspond to a step in evolution in which this sensory-cognitive correspondence emerged. Cognitive and sensory started to resonate, as one might say.

Could Galois groups provide a representation for the discrete sub-groups of isometries and tangent space rotations of embedding space?

I have already earlier considered the possibility that Galois groups could provide representations for the finite sub-groups of isometry groups of $H = M^4 \times CP_2$ and $M^8 = M^4 \times E^4 = M^2 \times E^2 \times E^4$, see for instance [L43].

1. A natural looking assumption is that only finite discrete sub-groups having a hierarchical decomposition in terms of normal sub-groups characterizing Galois extensions and having thus order equal to dimension of extension would be allowed.

   In case of sub-groups of the rotation group, one can of course consider also sub-group generated as products of discrete sub-groups but they have infinite number of elements, which does not conform with the idea about finiteness of cognition. For instance, one can take Platonic groups and groups C_n and D_{2n} such that there rotation axis does not go through a point of Platonic solid and generate the product group. This group would have the product of Galois groups as Galois group. One could think that also these are allowed if one has finite measurement resolution and cognitive resolution. This brings in the notion of approximation, which might have emerged in cognitive evolution too.

2. In terms of polynomials defining the space-time surface in M^8 as algebraic surface, one would have $P = P_1 \circ ....P_N \circ P_{gr}$. The Galois group associated with gravitational polynomial P_{gr} of degree n_{gr} would be normal sub-group of the entire Galois group and the Galois group of $P_1 \circ ....P_N$ would be factor group. This polynomial would correspond to higher evolutionary level and perhaps consciousness not directly related to embedding space geometry.

   G_{gr} would be sub-group of embedding space isometries and vielbein rotations and therefore have the characteristic decomposition to a direct product. Direct product decomposition could be replaced with sub-direct product decomposition for sub-groups of direct product. Product- or semi-direct product decomposition would correspond to that assumed for the original proposal and interpreted in terms of many-sheetedness over M^4 *resp.* CP_2 (flux tube bundles in M^4.

3. $M^8 - H$ duality forces the identification of the direct product as four-fold product of discrete sub-groups of $SU(2)$ appearing in McKay correspondence and to the special role of icosahedral group and its covering. As found in the introduction, the condition that the Gal_{gr} is discrete finite sub-group of product of M^8 and H isometries leads to a unique identification for this group as $I \times \overline{I} \times \overline{I} \times \overline{I}$, where I is icosahedral group and $\overline{I}$ its covering, and predicts correctly the value of G.

The assumption that the product of discrete isometry groups of the factors of embedding space is representable as Galois group of Galois extension representable in terms of a polynomial can be criticized. Can the Galois group for Galois extension of rationals defined by irreducible polynomial be a direct product of Galois groups for extensions?

1. The answer to the question can be found from web (`http://tinyurl.com/sj26xrc`): it is found that this is possible for Galois extensions if the product of extensions is the extension and the intersection of extensions consists of rationals. This question is physically highly relevant since Z_6 should have representation as Galois group having interpretation as direct product of centers of $SU(2)$ and $SU(3)$.

2. If this were not the case, one would be in trouble since this would exclude representations of the products $G_1 \times G_2$ of discrete sub-groups associated with isometries H and M^8 as Galois groups. One can of course think of having discrete sub-groups of $G_1 \times G_2$ having a lower order with direct products of sub-groups of G_i excluded. These are possible. $Z_2 \times Z_2$ allows the sub-groups $\{(0,0),(1,0)\}$, $\{(0,0),(0,1)\}$, and$\{(0,0),(1,1)\}$ and these are not products.

3. More generally, one could have a semi-direct product of normal sub-groups of $H_1 \subset G_1$ and $H_2 \subset G_2$ (`http://tinyurl.com/zhx5xpz`). This implies a correlation between the discrete isometries of the factors of embedding space, which would have physical interpretation. Semi-direct product allows surjective projections to $p_i : G_i \to H_i$ with normal sub-groups N_i as

kernels. The product group $G_1/N_1 \times G_2/N_2$ is the graph of isomorphism $G_1/N_1 \equiv G_2/N_2$. This obviously poses strong conditions on the groups. For $G_1 = G_2$ one can would have $N_1 = N_2$. Since Z_2 is always normal sub-group, one would obtain an acceptable group in this manner if both factors have even order, and the order would be reduced by factor 1/4. The orders of the acceptable sub-groups are factors of $ord(G_1) \times ord(G_2)$.

Remark: One should be of course be very cautious in considering the isometry groups. For instance, could the discrete sub-groups automorphism group G_2 of octonions be relevant in M^8 picture? One can also ask whether the finite discrete sub-groups of $SO(7)$ as maximal compact subgroup of $SO(1,7)$ might be relevant.

Genetic code and geometric consciousness

TGD predict at least two representations of genetic code. The first representation is in terms of dark photon triplets and second representation in terms of dark proton triplets.

TGD based model for genetic code based on bio-harmony realizes genetic code as a code for communications by dark photons. Triplet of dark photons having interpretation as 3-chord of bio-harmony is the basic idea. Icosahedral and tetrahedral geometries connect bio-harmony with geometry [L1, L30].

1. 12-note scale is represented as Hamiltonian cycle at icosahedron having 12 vertices. By assigning to edge of the Hamiltonian cycle quint (scaling of frequency by factor 3/2), the Hamiltonian cycle defines a harmony with 20 3-chords assignable to the triangular faces of the icosahedron. Hamiltonian cycles are characterized by their symmetry group S, which is Z_6, Z_4 and Z_2 (here one has two variants one depending on whether Z_2 represents reflection or rotation by π) or Z_1 (no symmetry, disharmony). By combining 3 Hamiltonian cycles with symmetries Z_6, Z_4, and Z_2 one obtains 60 3-chords.

2. One can assign to given 3-chord DNA codon and the analog amino-acid as the orbit of this chord under the symmetry group of the cycle. One almost obtains vertebrate genetic code with correct number of DNA codons associated with given amino-acid as number of faces at the orbit associated with it. Only 4 amino-acids and 4 DNA codons are missing. Tetrahedral harmony defined by unique Hamilton cycle gives the remaining 4 chords assignable to the triangular faces of tetrahedron. The outcome is vertebrate genetic code.

3. Icosahedron is in a unique position. Icosahedron has 17 Hamiltonian cycles whereas tetrahedron cube and dodecahedron have only 1 and octahedron 2. In case of dodecahedron the Hamiltonian cycle divides the dodecahedron to two identical parts with 6 pentagons suggesting that the the symmetry group is Z_6 and the number of amino-acids is 2.

4. There is large number of bioharmonies obtained by combining unique Z_6 harmony with pairs of Z_4 and Z_2 harmonies. Since music expresses and induces emotions, the identification would be as correlates for fundamental emotion/moods appearing already at molecular level, and perhaps even at deeper levels [L23]. The interpretation of codon as 6-bit would correspond to the standard reductionistic view about information represented as bit sequences. Harmony would code for the holistic aspects of information. These two views would correspond to intelligence in the usual sense and emotional intelligence.

Second representation of genetic code is in terms of dark nuclei consisting of sequences of dark protons triplets [L3, L41]. Codon corresponds to an entangled state of 3 dark protons forming a linear or circular structure with ordering of protons. The dark protons sequences associated with flux tubes parallel to ordinary DNA double strands would provide pairing of dark and ordinary DNA. Also RNA, tRNA, and amino-acids would be represented as dark proton triplets and DNA-amino-acid correspondence has a natural description.

One can raise questions about the interpretation of these two representations of the genetic code (and also about chemical representation).

1. Could genetic code be represented in terms of bio-harmony provide a quantum representation for two Platonic solids: icosahedron and tetrahedron, perhaps their product in $M^4 \times CP_2$. This would answer the question why both icosahedron and tetrahedron. An alternative

interpretation is that one has product of isometries and tangent space rotations for M^4 (or CP_2).

Could genes somehow represent concretely information about embedding space geometry and its symmetries - could one even imagine that genes are kind of statements? Could also dark proton representation have interpretation as a concrete representation in sensory realm.

2. One can raise questions about the bio-harmony. Why just 3 Hamiltonian cycles at icosahedron plus tetrahedral cycle? Could these 4 factors correspond to the 2+2 factors due to the $M^4 \times CP_2$ isometries and tangent space rotations. One would have representation for all these factors. But why one of them would be tetrahedron rather than icosahedron in which case one would have 80 codons? Why the symmetry groups S of Hamiltonian cycles would be Z_6, Z_4 and Z_2?

   Remark: Tetrahedral symmetries and orientation preserving octahedral symmetries are sub-groups of icosahedral symmetries (`http://tinyurl.com/vav2n2r`).

3. What about representation of color symmetries of CP_2 Platonic solid in terms of dark codons? Could one assign to dark codon formed by protons a representation in $3 \otimes 3 \otimes 3 = 10 \oplus 8 \oplus 8 \oplus 1$ to get colored variants of genetic code. Genes would have vanishing total color. Can one consider representation of color as a subgroup of Galois group. Also more general Galois groups can be considered and genes as units would be defined as Galois singlets [L41].

Could the notion of genetic code generalize to the level of more general Galois groups.

1. Could one consider a generalization of the genetic code to cognitive representations based on Galois group and its coset groups. Restrict first the consideration to any finite discrete subgroup of isometries of H or M^8. Represent it physically in M^4 or CP_2 as a discrete structure analogous to Platonic solid. Form all Hamiltonian paths in the discretization and identify the n-D basic cells of this n-D structure as basic entities - analogs of DNA codons/chords. Identify the orbits of these entities under symmetry group of the cycle as analogs of amino-acids. Define the analog of genetic code as in the case of ordinary genetic code.

2. Could one imagine cognitive representation of arbitrary Galois group in terms of wave functions in group or its coset space. Could one consider generalization of bio-harmony in terms of Hamiltonian cycles in this coset space. Could one assign analogs of DNA codons to the faces of the polyhedron and could amino-acids correspond to the orbits of the faces under symmetries of the Hamiltonian cycle? Amino-acid wave functions would be constant at the orbits of the symmetry group of the cycle.

3. The relation to the model of "small" state function reductions (SSFRs) [L43] is interesting. SSFRs would have an interpretation as cognitive measurements in Galois group of extension. Let E be the extension of rationals and F the largest sub-field of E: let the corresponding Galois groups be G and H. The reduction would be a cascade starting with a reduction of the wave function in Galois group of E/F to a product of wave functions in G/H and H. At the next step same would take place for H and after finite number of steps one would have full reduction [L43].

   These reduction cascades provide a model for cognitive processing as cognitive quantum measurements. This process brings in mind the translation of DNA to amino-acids. Could map to amino-acid involving transition from I to sub-group I/S, S the symmetry group of bio-harmony, be analogous to a state function reduction.

6 TGD inspired solution to three cosmological and astrophysical 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.

6.1 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.

6.1.1 Observations

The blog posting in Tallbloke's talkshop titled "*Evidence for a 160 minute oscillation affecting Galaxies and the Solar System*" [L31] (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 [L31, E3] 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*" [E3] (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 $162\pm$ 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/yxcwh4rl`).

6.1.2 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 [L14] (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 [K3].

2. In TGD inspired biology the cyclotron frequencies define coordinating rhythms [K16, K15] and the recent proposal [L36] (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 [L18]. 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 [**?**].

4. 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.

6.2 26 second pulsation of Earth: an analog of EEG alpha rhythm?

There is an interesting article in Discover Magazine with title "*The Earth Is Pulsating Every 26 Seconds, and Seismologists Don't Agree Why*" (`https://cutt.ly/ogI6soU`). That mini earthquakes would appear with a period of 26 seconds is a rather fascinating possibility and one can ask what the TGD based explanation for the poorly understood origin of the rhythm might be.

6.2.1 What has been observed?

The pulsations are Rayleigh waves in which the motion of the mass is vertical. The source of these pulsations can be located near the coast of the Gulf of Guinea. The amplitude of pulsations is largest during storms and during summer time, which suggests that ocean waves feed energy to some kind of waves. The first proposal is that deep ocean waves striking at the shore are the source of the pulsations. The problem is that the periods of these waves vary up to 20 s and shorter than the period 26 s of the pulsations.

Second hypothesis suggests that these microseisms are a form of harmonic tremor associated with the magmatic activity beneath the South Atlantic Ocean. The source is located suspiciously near a large volcano on the island of Sao Tome in the Bight of Bonny proposed to be the source. Also some other volcanoes are accompanied by microseism but the problem is why not all volcanoes would serve as sources.

The popular article talks about periodic pulsations and calls them mini earthquakes. What does this imply if one assumes that the author of the article is using the words in precise sense?

1. Stresses in the Earth's crust are involved with seismic waves. There are three basic kinds of stresses. The stress can due to the compression or stretching: in this case one speaks of tension. This could cause an oscillation. Oscillating string is a very simple example. Pulsations would be oscillations in the vertical direction. This phenomenon could be purely classical and involve no quantum jumps.

2. Ordinary earthquakes are however generated by shear stress: in an earthquake two parallel layers of rock touch each other in a fault. Faults need not be non-horizontal. When a large enough external force parallel to the fault acts on the second layer, the friction fails to keep the pieces together, and the layers start to slip. This event would be naturally quantum jump by its discontinuity. A phenomenological description is in terms of catastrophe theory but there is no proper classical description for what really happens when slippage starts.

3. Periodic mini earthquakes result if these slippages are induced by a periodic force acting on the other piece of rock in the direction of the fault. The analog of local pulsation would require a nearly vertical fault. The challenge would be to explain this periodic force. Standard physics might satisfactorily explain the periodic force and provide an estimate for the period but the description of the discontinuous transition might require TGD based quantum theory.

For the purpose of building a simple mental model, consider a 2-D lattice like structure consisting of cylindrical tectonic plates touching each other. At the border of the abyss at which the water depth suddenly increases deep ocean waves would act as an oscillating pressure to a cylinder and force it to oscillate.

If pulsations are indeed in question, the resulting horizontal motion of cylinders should be transformed to vertical motion. How this could be achieved? The pressure of ocean waves causes a compression in the horizontal direction. Since the material in question is incompressible and therefore preserves its volume, the cylinder must stretch in the vertical direction. The non-linearity of the coupling making possible period doubling could be due to the fact that the vertical stretching is a secondary effect. In the situation considered the coupling could be especially strong and make possible period doubling. The nearness of the volcano could increase the strength of coupling.

6.2.2 Could period doubling be involved?

Pulsations represent a special case of microseismic waves.

The microseism spectrum involves two parts: first part the period extends to 15 s as for deep ocean waves and for the second the frequencies are above 30 s and extend to 300s. However, 30 s is rather near to 26 seconds. If there is a coupling of deep ocean waves arriving at shore with microseism waves, one must explain how the almost period doubling results. In general linear coupling between oscillations preserves frequency so that non-linearity suggests itself. What comes in mind is that the system exhibits for frequency around $T = 13$ s a period doubling occurring universally in non-linear systems near chaos. Originally closed orbits in the configuration space of the system with period T are transformed in bifurcation to orbits with period $2T$. Why should $T = 13$ s be so special? In the TGD Universe, magnetic body carrying dark matter as $h_{eff} = nh_0$ phases acts as master controlling ordinary matter. The basic rule is that $h_{eff} \to nh_{eff}$ scales the energies $E = h_{eff}f$ of say phonons by n. The frequencies for the transitions preserving energy are scaled by $1/n$. Could the period doubling correspond to a transition $h_{eff} \to 2h_{eff}$ at MB and occur for $T = 13$ s, which could correspond to a cyclotron frequency of 1/13 Hz for MB. Quite generally, the cyclotron frequencies of MB of Earth would couple resonantly to various frequencies appearing in the dynamics of ordinary matter with $h_{eff} = h = 6h_0$. This would make the control possible. For $B = 2^{-7}B_{end}$ with $B_{end}02/B_E/5$, $B_E = .5$ Gauss, the cyclotron period of iron ion would be near 13 s. 25.6 Hz is rather near to 26 Hz and corresponds to 2^8:th sub-harmonic of the alpha rhythm 10 Hz, which suggests period doubling appearing in the approach to chaos as an explanation: 8^{th} period doubling of EEG alpha frequency could be in question!

6.2.3 Trying to understand the pulsation frequency

Could one understand the origin of the frequency 26 s in TGD framework as reflecting the presence of magnetic body (MB)? First some background about TGD.

1. TGD based quantum theory relies on zero energy ontology [L35] (`https://cutt.ly/jgI6du1`) and predicts quantum coherence in all scales being assignable to the magnetic bodies of systems consisting of ordinary matter. MBs would carry dark matter as $h_{eff} = n \times h_0$ macroscopically quantum coherent phases.

2. Ordinary ("big") state function reductions (BSFRs) would change the arrow of time and this implies that they look like deterministic smooth time evolutions leading to the final state of BSFR. The world would be quantum coherent but look classical in all scales! The change of the arrow of time leads to a radically new view about self-organization and about biology and also self-organized quantum criticality emerges naturally and leads to the emergence of "breathing systems" so that the applications to living systems are natural. In fact, evidence for very simple "breathing" systems is emerging [L34] (`https://cutt.ly/QgI6fuE`).

   Earthquakes have some strange features and this led to the proposal that earth quarks could involve BSFR in macroscopic scales at the level of MB of Earth [L32] (`https://cutt.ly/ogI6gc3`). Could also these mini earthquakes involve BSFRs? Could they be interpreted as a sequence of life cycles for a conscious entity with a life time of about 26 seconds assignable to Earth?

3. It is known that electromagnetic activity accompanies Earth quarks and this activity is such that the interpretation in terms of time reversal suggests itself. Could 26 seconds define a period for an analog of alpha rhythm in EEG? There is also another strange rhythm with a period of 160 minutes assignable to astrophysical systems and I have proposed an interpretation as a "cosmic" alpha rhythm [L31] (`https://cutt.ly/SgI6h92`).

This picture leads to ask whether the p-adic length scale hierarchy predicted by TGD could provide some understanding concerning the period of $T = 26$ seconds associated with the pulsations.

1. TGD predicts a hierarchy of p-adic length scales $L_p \propto p^{1/2}$, $p \simeq 2^k$, $k > 0$ preferred integer, coming as half octaves. TGD does not deny the possibility of scaled variants of various par-

ticles. For instance, electron could correspond to several integers k with masses proportional to $2^{k/2}$).

2. Secondary p-adic length scales correspond to scales $p^{1/2}L_p \propto p$. There also tertiary etc. time scales forming a fractal hierarchy coming in powers of$p^{1/2}$ and by p-adic length scales as preferred half octaves.

3. For instance, electron corresponds to p-adic prime $p = 2^{127} - 1$ (the largest Mersenne prime, which does not yet correspond to super-astrophysical length scale). Secondary p-adic length scale corresponds to a period $T_e \simeq .1$ seconds. This is a fundamental biorhythm appearing in alpha band of EEG. Also quarks correspond to secondary p-adic length scales which correspond to human time scales.

   $T = 26$ seconds is rather precisely equal to $2^8 \times T_e$, $T_e = .1$ seconds: the relative error is 1/64 or about 2 per cent. A scaled version of electron with mass $m = m_e/2^4 \simeq 32$ keV would correspond to 25.6 seconds. The p-adic prime $p \simeq 2^k$, $k = 127 + 8 = 135$ defining p-adic scale about .4 Angstrom. This is not far from Bohr radius $a_B = .53$ Angstrom for hydrogen atom.

Of course, the new dark particle need not be electron. One can consider more detailed attempts to understand the situation.

Option I:

The first attempt involves the notion of electropion or more generally, leptopion, see [K25] (`http://tgdtheory.fi/pdfpool/leptc.pdf`) for which there is empirical support and empirical evicence that ordinary pion allows p-adically scaled up variants.

1. The scenaro would be based on axion-like states proposed also as candidates for dark matter predicted by TGD. They would be indeed dark also in TGD but in TGD sense being particles having $h_{eff} = n \times h_0 > h$. This would explain why they are not seen in decay widths in particle accelerators (and excluding them).

2. There is evidence for electropion with mass $2 \times m_e$ (already from 1970's) decaying to an electron-positron pair but forgotten since it does not conform with the standard model (it would increase decay widths of weak bosons). TGD provides a model for this state and predicts similar states for muon and tau and evidence also for these states have been found but also forgotten.

TGD also suggest fractally scaled variants of pion states with different p-adic length scales $p \propto 2^k$ and there is empirical evidence for these states with masses both larger and smaller than pion mass.

1. One can also imagine scaled variants of electropion with different p-adic lengths scales. The primary p-adic time scale assignable to electropion scales corresponds to $k \leq 127$. How to estimate k?

   If the mass squared (conformal weight is additive in p-adic mass calculations then mass squared of electropion is $m^2 = 2m_e^2$ giving $m = 2^{1/2} \times m_e$ for $k = 127$. Correct mass requires $k_e = 127 \to 126$. Compton time of electropion would be $T(electropion, 126) = T_c(126, e)/2$, where $T_c(126, e)$ is the Compton time of electron with $k = 126$.

   The secondary p-adic time Compton time associated with the scaled variant of $k = 126$ electropion corresponds to $T(electropion, 126 + \Delta k) = 2^{\Delta k} T_e/2$. One must have $\Delta k = 8 + 2 = 10$ and $k = 137$. Amusingly, $k = 137$ corresponds to atomic length scale and to fine structure constant. This co-incidence could be regarded as a cosmic joke.

Why this atomic length scale, or rather the corresponding secondary p-adic length scale of scaled electropion, would be associated with the Earth's pulsations? Electropions should be dark and perhaps form a coherent state as in the model for the production of anomalous electron-positron pairs based on electropion involving in an essential manner non-orthogonal electric and magnetic fields of colliding nuclei?

Option II: The second proposal is based on TGD inspired quantum biology involving Bose-Einstein condensates of Cooper pairs of electrons, protons, and fermionic ions and also of bosonic ions at magnetic flux tubes and characterized by effective Planck constant $h_{eff} = nh_0$, $h = 6h_0$, making possible quantum coherence in length scales longer than Compton length.

1. Consider the Bose-Einstein condensate of electron Cooper pairs. Electron Cooper pairs has Compton length equal to $L_{2e} = L_e/2$, L_e the electronic Compton length. Secondary Compton time equals to $T_{2e}^{2)} = 2^{127/2}T_e/2 = .05$ s. Superconductivity in longer length scales than Compton length requires $h_{eff} > h$. The scaled up Compton scale $L_{n,2e} = nL^{2e}$ gives the coherence length of a superconductor and the secondary Compton time scales to $nT_{2e}^{2)} = .05n$ s. This time equals to $T = 25.6$ s for $n = 2^9$. The interpretation in terms of period doubling can be considered.

2. The general hypothesis [K10] is that there is resonance between dark and p-adic length scales so that this dark scale would correspond to identical p-adic length scale which would correspond to $L(k = 127 + 18 = 145) \sim 1.25$ nm equal to the transversal length scale for DNA.

3. TGD predicts that ordinary dark DNA in aqueous environment is accompanied by dark DNA realized as flux tubes carrying dark proton triplets realizing genetic code. Also amino-acids would be accompanied by these dark proton triplets and electrons would neutralize proteins charge which would be 3 proton charges per amino-acid. This would suggest that this scale relates to dark DNA, RNA, and proteins, which would involve space-time sheets which are electronic super conductors, and that the 26 second rhythm reflects the presence of water.

Option III: This alternative is nearest the idea about 260 Hz rhythm as analog of alpha rhythm. Iron ion has cyclotron frequency 10 Hz in B_{end}. Period doublings could correspond to the scalings of B_{end} by powers 2^{-n} of two scaling the cyclotron frequency by factor 2^{-2n}. The area of the flux tube would be scaled up by 2^n. If h_{eff} is scaled by 2^n, the energies are unaffected. For $n = 8$ the cyclotron frequency of iron ion would be near to 25.6 s. Could also the powers $2^{-n} \times 10$ Hz appear in the microseismic spectrum as period doubled alpha rhythm in the approach to chaos?

Could 26 second rhythm be kind of a bio-rhythm for Earth analogous to heart-beat or breathing? These two rhythms are highly varying and assignable to self-organization. EEG alpha rhythm is however universal. Could the Earthly bio-rhythm be analogous to the alpha band in the analog of EEG of Earth with frequencies scaled down by factor 1/256?

Each period would correspond to a mini earth quake. Also the ordinary EEG would involve similar BSFRs as an analog of sleep-awake rhythms and all bio-rhythms could be this kind of sleep-awake rhythms. One could of course check whether the 26 second rhythm has an electromagnetic analog?

There exists also another analogous rhythm, the 160 minute rhythm assignable to many astrophysical objects. I have proposed an interpretation as a kind of cosmic alpha rhythm.

1. 160 minute period is obtained from 26 second rhythm by scaling by a factor about $369 \simeq 2^{8.5}$ with error of 2 per cent - half octave again.

2. For the electro-pion option, one can think that one scales electropion with $k = 127$ having mass $2^{1/2} \times m_e$ to $k = 127 \to 127 + 17 = 144$ to get secondary Compton time scale $2^{16+1/2)}T_e = 154.5$ minutes not too far from 160 seconds. The interpretation as 17^{th} period doubling for $k = 127$ electro-pion with $T_c = \sqrt{2}T_e$ could make sense. There is indeed evidence for the period doubling of pion-like state. $f_c = f_e/\sqrt{2} \simeq 7.1$ Hz is lower than the nominal value $f_S = 7.8$ Hz of the lowest Schumann frequency. The cyclotron frequency of K^+ in B_{end} is 7.7 Hz and rather near to f_S.

3. For the Cooper pair option one could argue that since h_{eff} is integer valued, one can allow a value of n near to $2^{17.5} \simeq 185364$: this would give p-adic length scale $L(162)$, $L(163)$, which corresponds to one of the miracle length scales $k \in \{151, 157, 163, 167\}$ defining scales assignable to DNA coiling, would have been a more desired outcome.

6.3 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 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 [L7] (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.

1. 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 biomatter 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.

2. 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) [L18] (see http://tinyurl.com/y63l7624). 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.

1. 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. hese 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 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 [L29] 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 hat 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 m mediating gravitational interaction? The ratio of Planck constants would be

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

   This would demand

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

   (b) Note that the 160 minute period was discovered in the dynamics of Sun: no mechanism is not know 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?

7 Fast radio wave bursts: is life a cosmic fractal?

I encountered a highly interesting popular article with title "*Mysterious 'fast radio burst' detected closer to Earth than ever before*" (`https://cutt.ly/QdNX5Xc`)

Fast radio wave bursts (FRBs) arrive from a distance of hundreds of millions of light years - the scale of a large void. If the energy of FRBs is radiated isotropically in all directions - an assumption to be challenged below - the total energy is of the same order of magnitude that the energy of the Sun produced during a century. There are FRBs repeating with a period of 16 days located to a distance of 500 million light years from Earth.

The latest bursts arrive from a distance of only about 30 thousand light years from our own galaxy Milky Way described in the popular article can be assigned with magnetar (see `https://cutt.ly/udNMKRF`), which is a remnant of neutron start and has extremely strong magnetic field of about 10^{11} Tesla.

7.1 Basic findings

Below is the abstract of the article [E8] (`https://cutt.ly/sdNX69z`) reporting the discovery.

> *We report on International Gamma-Ray Astrophysics Laboratory (INTEGRAL) observations of the soft γ ray repeater SGR 1935+2154 performed between 2020 April 28 and May 3. Several short bursts with fluence of $\sim 10^{-7}$–10^{-6} erg cm^{-2} were detected by the Imager on-board INTEGRAL (IBIS) instrument in the 20–200 keV range. The*

burst with the hardest spectrum, discovered and localized in real time by the INTEGRAL Burst Alert System, was spatially and temporally coincident with a short and very bright radio burst detected by the Canadian Hydrogen Intensity Mapping Experiment (CHIME) and Survey for Transient Astronomical Radio Emission 2 (STARE2) radio telescopes at 400–800 MHz and 1.4 GHz, respectively.

Its lightcurve shows three narrow peaks separated by ~ 29 *ms time intervals, superimposed on a broad pulse lasting* ~ 0.6 *s. The brightest peak had a delay of 6.5* $\pm$ *1.0 ms with respect to the 1.4 GHz radio pulse (that coincides with the second and brightest component seen at lower frequencies). The burst spectrum, an exponentially cutoff power law with photon index* $\Gamma = 0.7^{+0.4}_{-0.2}$ *and peak energy* $E_p = 65 \pm 5$ *keV, is harder than those of the bursts usually observed from this and other magnetars.*

By the analysis of an expanding dust-scattering ring seen in X-rays with the Neil Gehrels Swift Observatory X-ray Telescope (XRT) instrument, we derived a distance of $4.4^{+2.8}_{-1.3}$ *kpc for SGR 1935+2154, independent of its possible association with the supernova remnant G57.2+0.8. At this distance, the burst 20–200 keV fluence of* $(6.1 \pm 0.3) \times 10^{-7}$ *erg cm*$^{-2}$ *corresponds to an isotropic emitted energy of* $\sim 1.4 \times 10^{39}$ *erg. This is the first burst with a radio counterpart observed from a soft* γ *ray repeater and it strongly supports models based on magnetars that have been proposed for extragalactic fast radio bursts.*

What could be the interpretation of the finding in the TGD framework? The weirdest feature of the FRB is its gigantic total energy assuming that the radiation is isotropic during the burst. This assumption can be challenged in the TGD framework, where the stellar systems are connected to a monopole flux tube network and radiation flows along flux tubes, which can also branch. This brings strongly in mind the analog of a nervous system in cosmic scales and this analogy is used in what follows.

7.2 TGD based model for the FRBs

TGD based model is motivated by the fractality of the TGD Universe and zero energy ontology (ZEO) based view about quantum measurement theory predicting that self-organization correspond in all scales corresponds to a formation systems living in at least primitive sense.

An essential element is the hierarchy of effective Planck constants $h_{eff} = nh_0$ implied by adelic physics formulating the number theoretic vision about TGD. h_{eff} labels phases of ordinary particles behaving like dark matter and n corresponds to the dimension of extension of rationals. The first generalization of Nottale's hypothesis $\hbar_{gr} = GMm/v_0$ to be discussed below in more detail was to $h_{eff} = \hbar_{gr}$. The recent form of the hypothesis is that $\hbar_{gr}$ corresponds to a large integer factor of $h_{eff}/h_0 = n$.

The differences between TGD based view about classical fields lead to the notion of magnetic body consisting of flux quanta. Entire Universe would be a fractal network of nodes (say stars, planets, etc... identifiable as flux tube tangles identifiable as spaghetti like structures) connected by flux tubes, which can come in two varieties depending on whether the magnetic flux associated with them vanishes or is monopole flux.

7.3 Heuristic picture

With this background in mind one can start the heuristic model building.

1. The duration of pulses is few milliseconds: the duration of nerve pulses is the same. Is this a wink-wink to the Poirots of astrophysics?

2. Bursts can arrive regularly - for instance with a period of $T = 16.35$ days [E5] (`https://cutt.ly/xdNMjQK`). This brings in the mind of astro-Poirot biorhythm, in particular EEG rhythms. This would not be the only such rhythms: also the period of $T_{alpha} = 160$ minutes, for which have proposed an interpretation as a cosmic analog of alpha rhythm is known [L31]. The ratio $T/T_\alpha = 147.15$ would give for the analogous brain rhythm the value of 14.7 seconds.

3. Let us assume that stellar systems indeed form an analog of neural network connected by flux and assume that the topology of this network is analogous to that defined by axons. In TGD framework neural communications between neurons occur actually by using dark photons with effective Planck constant $h_{eff} = nh_0$ along the flux tubes with the velocity of light so that feedback from brain and even from the magnetic body of brain back to sensory organs as virtual sensory input becomes possible. The function of nerve pulses is to connect the outgoing branch of the flux tube associated with the axon and those associated with dendrites of the post-synaptic neuron to a longer flux tubes by using neurotransmitters as relays.

4. The stellar object as an analog of a neuron would send its dark photon signals along the flux tube assignable to a single axon. Axon would later branch to dendrites arriving to other stellar systems and eventually perhaps to planets as analogs of synaptic contacts. An interesting question is whether also the analogs of nerve pulses and neurotransmitters acting as relays in the synaptic contacts defined by planets could make sense. What could nerve pulses propagating along the flux tube correspond to?

   Remark: In the TGD based model of brain there would be also flux tube network analogous to the meridian system of Eastern medicine and responsible for the holistic and spatial aspects of consciousness since more than one flux tube can emanate from a given node making possibly non-linear networks [L8]. Nervous system with tree- like structure would be responsible for the linear and temporal aspects of conscious experience. Meridian system would be a precedessor of the neural system.

5. The distances of FRBs are of the order of large voids having galaxies at their boundaries and forming lattice-like networks possibly assignable to the tessellations of 3-D hyperbolic space defining cosmic time= constant surfaces. This kind of tessellations could accompany also brain [L39]. In the fractal Universe of TGD one can wonder whether these voids are analogs of cells or even neurons and form cosmic biological organisms with flux tubes forming a network allowing communications.

7.4 The total emitted energy if it is analogous to nerve pulse pattern along flux tube directed to solar system

The basic implication is that the energy of the emitted radiation could be dramatically smaller than that predicted by am isotropic radiation burst. It is interesting to look whether the proposed picture survives quantitative modelling.

1. The reduction factor r for the total emitted energy would be essentially $r = S/A$, where S is the area of the "axonal" flux tube and $A = 4\pi R^2$ is the surface area of the magnetar. One must estimate the value of r.

2. Flux quantization for a single sheet of the many-sheeted magnetic flux tube involved would give $eBS = \hbar_0$ $h = 6h_0$ [L5, L21]. The general order of magnitude estimate is $eB \sim \hbar_0/S$. If each sheet carries out the same energy, the number of sheets is $n = h_{eff}/h_0$ and the effective area of a flux tube is $S = \hbar_0/eB$. Does the magnetic field assigned with magnetar correspond to a single sheet or to all sheets? If the field is measured from cyclotron energies assuming $h_{eff} = h$ it would correspond to all sheets and the measured magnetic field would be the effective magnetic field $B_{eff} = nB/6$ for $h = 6h_0$.

3. The branching of the flux tube could correspond to the splitting of the many-sheeted flux tube to tubes with smaller number of sheets and involve reduction of h_{eff}. This would give the estimate $r = \hbar_0/eBA$. Magnetic field of 1 Tesla corresponds to a unit flux quantum with radius - magnetic length - about 2.6×10^{-8} meters. Assuming the estimate $R = 20$ km for the magnetar radius, one has $r \sim 10^{-25}/6$.

4. The estimate for the total emitted energy assuming isotropic radiation is the energy radiated by the Sun during a century. Sun transforms roughly $E_{100} = 1.3 \times 10^{19}$ kg of mass to radiation during a century. This gives for the energy emitted in FRB the estimate $E = rE_{100} \sim 10^{-6}/6$

kg which is roughly 7.5 Planck masses $m_{Pl} \simeq 2.2 \times 10^{-8}$ kg $= 1.2 \times 10^{19}$ GeV. The order of magnitude is Planck mass. The estimate is of course extremely rough.

In any case, the idea that pulses could have mass of order few Planck masses is attractive. Note that a large neuron with radius about 10^{-4} meters has a mass of order Planck mass [L37].

5. From the total detected energy $dE/dS = 6.1 \times 10^{-7}$ erg m^{-2} $=3.8\times 10^9 eVm^{-2}$ and total radiated energy $E = 7.5 m_{Planck}$ one can estimate the total area S covered by the branched energy flux if it covers the entire area with a shape of disk of radius R. This gives some idea about how wide the branching is. The total energy is $E = (dE/dS) \times \pi R^2$ giving $R = \sqrt{E/\pi(dE/dS)} \simeq .9 \times 10^9$ m. The equitoral radius of the Sun is $R_{Sun} = .7 \times 10^9$ m. $R_{Sun} \sim .78R$ This conforms with the idea that the radiation arrives along the axon-like flux tube connecting Sun and the magnetar branching so that it covers entire Sun.

7.5 Is the ratio $\hbar_{gr}/\hbar$ equal to the ratio of the total emitted energy to the total energy received by Sun?

The ratio h_{eff}/h should be of the same order of magnitude as the ratio $X = E/E_{rad}$, where E_{rad} is the energy of the radio wave photon with frequency 1.4 GHz for $h_{eff} = h$: $X \sim h_{eff}/h$. The ratio $Y = X/(h_{eff}/h)$ should satisfy $Y \sim 1$.

1. To proceed further, one can use the TGD variant of Nottale's hypothesis. The hypothesis states that one can assign to gravitational flux tubes gravitational Planck constant $\hbar_{gr}$. The original hypothesis was $\hbar_{eff} = \hbar_{gr}$ and the more recent form inspired by the adelic vision states that h_{gr} corresponds to a large integer factor of h_{eff}. One has $\hbar_{gr} = GMm/v_0 = r_S m/2v_0$. Here M is the mass of the large object - now that of magnetar. m is the mass of the smaller quantum coherent object in contact with the gravitational flux tube mediating gravitational interaction as dark graviton exchanges.

   v_0 is a velocity parameter, which for Sun would be $\beta_{0,S} = v_0/c \simeq 2^{-11}$ from the model for the inner planets as Bohr orbits [E6] [K20, K13, K14, **?**].

2. The Planckian educated guess is $m \sim m_{Pl}$ so that one would have $\hbar_{gr}/\hbar = r_S(M)/(2L_{Pl}\beta_0)$, where L_{Pl} is Planck length and $r_S(M)$ is the Schwartshild radius of the magnetar. This would give $Y = X/(h_{gr}/\hbar) = .4$ if one has $r_S = 3$ km as for the Sun. r_S is probably large but smaller than magnetar radius about 20 km. The masses of the magnetars are in the range 1-2 solar masses. For $M = 2M_S$ one obtains $Y = .8$

   The rough estimate is not far from $Y = 1$ and suggests that the interacting quantum units at the receiving end have mass of order Planck mass. Interestingly, the mass of a large neuron with radius 10^{-4} m is about Planck mass [L37], which supports the view that quantum gravitation in the TGD sense is fundamental for life - even in the cosmic scales.

7.6 The parameter v_0 as analog of nerve pulse conduction velocity?

The physical interpretation of the velocity parameter v_0 is one of the key challenges of TGD.

1. The order of magnitude of v_0 is the same as for the rotational velocities in the solar system. I have considered a geometry based interpretation in [L19, L18] [K1].

2. The analogy with the neural system encourages the question whether v_0 could have a concrete interpretation as the analog of the nerve pulse conduction velocity assignable to the dark magnetic flux tubes connecting distant systems.

   In TGD framework nerve pulses [K18] are proposed to be induced by Sine-Gordon solitons for the generalized Josephson junctions assignable to the cell membrane and identifiable as transversal flux tubes assignable to various membrane proteins such as ion channels and pumps. The dark variants of the biologically important ions would give rise to the supra currents.

   Could the gravitational flux tubes analogous to axons have this kind of structure and give rise to generalized Josephson junctions with ions serving also in this case as current carriers?

To sum up, the proposed interpretation as cosmic neural networks conforms with the basic assumptions of TGD. Most importantly, quantitative predictions are correct. The picture is of course not deduce from axioms: this is pattern recognition with basic principles predicting a lot of new physics.

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

In TGD $\hbar$ is replaced with $\hbar_{eff} = nh_0 = nh/6$ [L5, L21, 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.

8.1 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 $2 \to 2$ 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 h_{eff} to guarantee the convergence of perturbation series.

2. For a gauge theory scattering of type $2 \to n > 2$ 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 $1/\hbar_{eff}$: $\alpha^2 m$ 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 $\hbar \to 0$ 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, $2 \to 2$ 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 $2 \to 2$ scattering is main provider of information. This leaves room for the possibility of $\hbar_{eff}$ hierarchy.

8.2 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 [K9, K24, K19].

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 [L9].

   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 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 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.

8.3 What about quantum gravitation for dark matter with large enough h_{eff}?

It is interesting to look what h_{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 $Z_1 Z_2 e^2$ 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 $GMm = l_P^2 Mm/\hbar_{eff}$ with Plack length identified as CP_2 radius R: $l_P = R$ [L26]. The independence of the cross section or $2 \to 2$ scattering on $\hbar_{eff}$ in lowest order holds true also now. $\sqrt{\hbar_{eff}} M/M_P = \sqrt{G} M = M l_P/\sqrt{\hbar}$ would serve as analog of e now.

2. In the lowest order the scattering amplitude for $2 \to 2$ scattering by graviton exchange should be essentially Fourier transform of Newton's gravitational potential at the static limit. The independence of $2 \to 2$ scattering cross section on h_{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 $Z_1 Z_2 e^2$ and both have dimension [$\hbar$]. Therefore the cross section for $2 \to 2$ 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 [E6] 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 [K20, K13, K14].

   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

$$(-\frac{\nabla_u^2}{2} + \frac{\beta_0^2}{u})\Psi = e\Psi \quad , \quad e = \frac{E\beta_0^2}{m} \quad , \quad u = GM = \frac{r_S}{2} \quad . \tag{8.1}$$

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

4. If gravitational Shrödinger equation makes sense, the gravitational analogs of atomic transitions should also make sense. For h_{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 [K13].

   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 $exp(ik.x) = 1 + ik \cdot x$ 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 orer 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 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 h_{eff}.

8.4 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 $2 \to 2$ 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.

REFERENCES

Theoretical Physics

[B1] Zuber J-B Itzykson C. *Quantum Field Theory.* Mc Graw-Hill, New York, 1980.

[B2] Ludl PO. Comments on the classification of the finite subgroups of SU(3), 2011. Available at: `https://arxiv.org/pdf/1101.2308.pdf`.

Cosmology and Astro-Physics

[E1] *Nat. V.*, 259:87, 1996.

[E2] *Astron. Nachr.*, 318:121–128, 1997.

[E3] Solar Activity, Wave of Kotov and Strange Coincidences, 2012. Available at:`https://lempel.pagesperso-orange.fr/soleil_onde_kotov_uk.htm`.

[E4] Evidence for a 160 minute oscillation affecting Galaxies and the Solar System, 2012. Available at:https://tinyurl.com/y5en9cxz.

[E5] The CHIME/FRB Collaboration. Periodic activity from a fast radio burst source. *Nature*, 582:351–355, 2020. Available at: https://www.nature.com/articles/s41586-020-2398-2. .

[E6] Nottale L Da Rocha D. Gravitational Structure Formation in Scale Relativity, 2003. Available at: https://arxiv.org/abs/astro-ph/0310036.

[E7] Kapner DJ et al. Tests of the Gravitational Inverse-Square Law below the Dark-Energy Length Scale. *Phys Rev Lett*, 98(021101), 2007.Available at: https://arxiv.org/abs/hep-ph/0611184.

[E8] Mereghetti S et al. INTEGRAL Discovery of a Burst with Associated Radio Emission from the Magnetar SGR 1935+2154. *The Astrophysical Journal Letters*, 2020. Available at: https://iopscience.iop.org/article/10.3847/2041-8213/aba2cf. .

[E9] Perivolaropoulos L and Kazantzidis L. Hints of Modified Gravity in Cosmos and in the Lab?, 2019. Available at:https://arxiv.org/pdf/1904.09462.pdf.

[E10] Sao CG et al Yang SQ. Measurements of the gravitational constant using two independent methods. *Nature*, 560:582–588, 2018. Available at:https://www.nature.com/articles/s41586-018-0431-5.

Fringe Physics

[H1] Modanese G. On the theoretical interpration of E. Podkletnov's experiment, 1996. Available at: https://www.gravity.org/ont.html.

[H2] Schnurer J. Demonstration of transient weak gravitational shielding by a YBCO LEVHEX at the super-conducting transition, 1999. Available at: https://www.gravity.org/exp.htm.

[H3] Nieminen R Podkletnov E. Weak gravitational shielding properties of composite bulk YBa2Cu3O7-x super-conductor below 70 K under electro-magnetic field, 1992. Available at: https://arxiv.org/abs/cond-mat/9701074. Report MSU-chem 95, improved version at https://arxiv.org/abs/cond-mat/9701074.

Books related to TGD

[K1] Pitkänen M. About the Nottale's formula for h_{gr} and the possibility that Planck length l_P and CP_2 length R are related. In *Dark Matter and TGD: https://tgdtheory.fi/tgdhtml/Bdark.html*. Available at: https://tgdtheory.fi/pdfpool/vzerovariableG.pdf, 2023.

[K2] Pitkänen M. About twistor lift of TGD? In *Quantum TGD: Part III. https://tgdtheory.fi/tgdhtml/Btgdquantum3.html*. Available at: https://tgdtheory.fi/pdfpool/hgrtwistor.pdf, 2023.

[K3] Pitkänen M. Are dark photons behind biophotons? In *TGD and Quantum Biology: Part I. https://tgdtheory.fi/tgdhtml/Bqbio1.html*. Available at: https://tgdtheory.fi/pdfpool/biophotonslian.pdf, 2023.

[K4] Pitkänen M. Comments on the recent experiments by the group of Michael Persinger. In *TGD and EEG: Part I. https://tgdtheory.fi/tgdhtml/Btgdeeg1.html*. Available at: https://tgdtheory.fi/pdfpool/persconsc.pdf, 2023.

[K5] Pitkänen M. Cosmic Strings. In *Physics in Many-Sheeted Space-Time: Part II. https://tgdtheory.fi/tgdhtml/Btgdclass2.html*. Available at: https://tgdtheory.fi/pdfpool/cstrings.pdf, 2023.

[K6] Pitkänen M. Criticality and dark matter: part II. In *Dark Matter and TGD: https://tgdtheory.fi/tgdhtml/Bdark.html*. Available at: https://tgdtheory.fi/pdfpool/qcritdark2.pdf, 2023.

[K7] Pitkänen M. Evolution of Ideas about Hyper-finite Factors in TGD. In *Topological Geometrodynamics: Overview: Part II. https://tgdtheory.fi/tgdhtml/Btgdoverview2*. Available at: https://tgdtheory.fi/pdfpool/vNeumannnew, 2023.

[K8] Pitkänen M. Expanding Earth Model and Pre-Cambrian Evolution of Continents, Climate, and Life. In *Physics in Many-Sheeted Space-Time: Part I. https://tgdtheory.fi/tgdhtml/Btgdclass1.html*. Available at: https://tgdtheory.fi/pdfpool/expearth.pdf., 2023.

[K9] Pitkänen M. From Principles to Diagrams. In *Quantum TGD: Part III. https://tgdtheory.fi/tgdhtml/Btgdquantum3.html*. Available at: https://tgdtheory.fi/pdfpool/diagrams.pdf, 2023.

[K10] Pitkänen M. Magnetic Sensory Canvas Hypothesis. In *TGD and Quantum Biology: Part I. https://tgdtheory.fi/tgdhtml/Bqbio1.html*. Available at: https://tgdtheory.fi/pdfpool/mec.pdf, 2023.

[K11] Pitkänen M. Magnetospheric Sensory Representations. In *Magnetospheric Consciousness. https://tgdtheory.fi/tgdhtml/Bmagnconsc.html*. Available at: https://tgdtheory.fi/pdfpool/srepres.pdf, 2023.

[K12] Pitkänen M. Massless states and particle massivation. In *p-Adic Physics. https://tgdtheory.fi/tgdhtml/Bpadphys.html*. Available at: https://tgdtheory.fi/pdfpool/mless.pdf, 2023.

[K13] Pitkänen M. Quantum Astrophysics. In *Physics in Many-Sheeted Space-Time: Part II. https://tgdtheory.fi/tgdhtml/Btgdclass2.html*. Available at: https://tgdtheory.fi/pdfpool/qastro.pdf, 2023.

[K14] Pitkänen M. Quantum gravity, dark matter, and prebiotic evolution. In *Evolution in TGD Universe. https://tgdtheory.fi/tgdhtml/Btgdevolution.html*. Available at: https://tgdtheory.fi/pdfpool/hgrprebio.pdf, 2023.

[K15] Pitkänen M. Quantum Mind and Neuroscience. In *TGD and EEG: Part I. https://tgdtheory.fi/tgdhtml/Btgdeeg1.html*. Available at: https://tgdtheory.fi/pdfpool/lianPN.pdf, 2023.

[K16] Pitkänen M. Quantum Mind, Magnetic Body, and Biological Body. In *TGD and Quantum Biology: Part I. https://tgdtheory.fi/tgdhtml/Bqbio1.html*. Available at: https://tgdtheory.fi/pdfpool/lianPB.pdf, 2023.

[K17] Pitkänen M. Quantum Model for Hearing. In *TGD and EEG: Part II. https://tgdtheory.fi/tgdhtml/Btgdeeg2.html*. Available at: https://tgdtheory.fi/pdfpool/hearing.pdf, 2023.

[K18] Pitkänen M. Quantum Model for Nerve Pulse. In *TGD and EEG: Part I. https://tgdtheory.fi/tgdhtml/Btgdeeg1.html*. Available at: https://tgdtheory.fi/pdfpool/nervepulse.pdf, 2023.

[K19] Pitkänen M. Some questions related to the twistor lift of TGD. In *Quantum TGD: Part III. https://tgdtheory.fi/tgdhtml/Btgdquantum3.html*. Available at: https://tgdtheory.fi/pdfpool/twistquestions.pdf, 2023.

[K20] Pitkänen M. TGD and Astrophysics. In *Physics in Many-Sheeted Space-Time: Part II. https://tgdtheory.fi/tgdhtml/Btgdclass2.html*. Available at: https://tgdtheory.fi/pdfpool/astro.pdf, 2023.

[K21] Pitkänen M. TGD and Potential Anomalies of GRT. In *Physics in Many-Sheeted Space-Time: Part I. https://tgdtheory.fi/tgdhtml/Btgdclass1.html*. Available at: https://tgdtheory.fi/pdfpool/granomalies.pdf., 2023.

[K22] Pitkänen M. TGD Based Model for OBEs. In *TGD Inspired Theory of Consciousness: Part III. https://tgdtheory.fi/tgdhtml/Btgdconsc3.html*. Available at: https://tgdtheory.fi/pdfpool/OBE.pdf, 2023.

[K23] Pitkänen M. TGD view about McKay Correspondence, ADE Hierarchy, Inclusions of Hyperfinite Factors, $M^8 - H$ Duality, SUSY, and Twistors. In *TGD and Hyper-finite Factors. https://tgdtheory.fi/tgdhtml/BHFF.html*. Available at: https://tgdtheory.fi/pdfpool/McKaygeneral, 2023.

[K24] Pitkänen M. The classical part of the twistor story. In *Quantum TGD: Part III. https://tgdtheory.fi/tgdhtml/Btgdquantum3.html*. Available at: https://tgdtheory.fi/pdfpool/twistorstory.pdf, 2023.

[K25] Pitkänen M. The Recent Status of Lepto-hadron Hypothesis. In *p-Adic Physics. https://tgdtheory.fi/tgdhtml/Bpadphys.html*. Available at: https://tgdtheory.fi/pdfpool/leptc.pdf, 2023.

[K26] Pitkänen M. The Recent View about Twistorialization in TGD Framework. In *Quantum TGD: Part III. https://tgdtheory.fi/tgdhtml/Btgdquantum3.html*. Available at: https://tgdtheory.fi/pdfpool/smatrix.pdf, 2023.

[K27] Pitkänen M. The Relationship Between TGD and GRT. In *Physics in Many-Sheeted Space-Time: Part I. https://tgdtheory.fi/tgdhtml/Btgdclass1.html*. Available at: https://tgdtheory.fi/pdfpool/tgdgrt.pdf., 2023.

[K28] Pitkänen M. Was von Neumann Right After All? In *TGD and Hyper-finite Factors. https://tgdtheory.fi/tgdhtml/BHFF.html*. Available at: https://tgdtheory.fi/pdfpool/vNeumann.pdf, 2023.

Articles about TGD

[L1] Pitkänen M. Geometric theory of harmony. Available at: https://tgdtheory.fi/public_html/articles/harmonytheory.pdf., 2014.

[L2] Pitkänen M. Could Podkletnov effect be understood using $h_{gr} = h_{eff}$ hypothesis? Available at: https://tgdtheory.fi/public_html/articles/Podkletnovagain.pdf., 2015.

[L3] Pitkänen M. About Physical Representations of Genetic Code in Terms of Dark Nuclear Strings. Available at: https://tgdtheory.fi/public_html/articles/genecodemodels.pdf., 2016.

[L4] Pitkänen M. Can one apply Occam's razor as a general purpose debunking argument to TGD? Available at: https://tgdtheory.fi/public_html/articles/simplicity.pdf., 2016.

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

[L6] Pitkänen M. LIGO and TGD. Available at: https://tgdtheory.fi/public_html/articles/ligotgd.pdf., 2016.

[L7] Pitkänen M. Cold fusion, low energy nuclear reactions, or dark nuclear synthesis? Available at: https://tgdtheory.fi/public_html/articles/krivit.pdf., 2017.

[L8] Pitkänen M. DMT, pineal gland, and the new view about sensory perception. Available at: https://tgdtheory.fi/public_html/articles/dmtpineal.pdf., 2017.

[L9] Pitkänen M. Does $M^8 - H$ duality reduce classical TGD to octonionic algebraic geometry? Available at: https://tgdtheory.fi/public_html/articles/ratpoints.pdf., 2017.

[L10] Pitkänen M. Does $M^8 - H$ duality reduce classical TGD to octonionic algebraic geometry?: part I. Available at: https://tgdtheory.fi/public_html/articles/ratpoints1.pdf., 2017.

[L11] Pitkänen M. Does $M^8 - H$ duality reduce classical TGD to octonionic algebraic geometry?: part II. Available at: https://tgdtheory.fi/public_html/articles/ratpoints2.pdf., 2017.

[L12] Pitkänen M. Does $M^8 - H$ duality reduce classical TGD to octonionic algebraic geometry?: part III. Available at: https://tgdtheory.fi/public_html/articles/ratpoints3.pdf., 2017.

[L13] Pitkänen M. Does valence bond theory relate to the hierarchy of Planck constants? Available at: https://tgdtheory.fi/public_html/articles/valenceheff.pdf., 2017.

[L14] Pitkänen M. Philosophy of Adelic Physics. Available at: https://tgdtheory.fi/public_html/articles/adelephysics.pdf., 2017.

[L15] Pitkänen M. Philosophy of Adelic Physics. In *Trends and Mathematical Methods in Interdisciplinary Mathematical Sciences*, pages 241–319. Springer.Available at: https://link.springer.com/chapter/10.1007/978-3-319-55612-3_11, 2017.

[L16] Pitkänen M. Re-examination of the basic notions of TGD inspired theory of consciousness. Available at: https://tgdtheory.fi/public_html/articles/conscrit.pdf., 2017.

[L17] Pitkänen M. About the Correspondence of Dark Nuclear Genetic Code and Ordinary Genetic Code. Available at: https://tgdtheory.fi/public_html/articles/codedarkcode.pdf., 2018.

[L18] Pitkänen M. About the physical interpretation of the velocity parameter in the formula for the gravitational Planck constant. Available at: https://tgdtheory.fi/public_html/articles/vzeronew.pdf., 2018.

[L19] Pitkänen M. About the physical interpretation of the velocity parameter in the formula for the gravitational Planck constant . Available at: https://tgdtheory.fi/public_html/articles/vzero.pdf., 2018.

[L20] Pitkänen M. Clustering of RNA polymerase molecules and Comorosan effect. Available at: https://tgdtheory.fi/public_html/articles/clusterRNA.pdf., 2018.

[L21] Pitkänen M. Dark valence electrons and color vision. Available at: https://tgdtheory.fi/public_html/articles/colorvision.pdf., 2018.

[L22] Pitkänen M. Dark valence electrons, dark photons, bio-photons, and carcinogens. Available at: https://tgdtheory.fi/public_html/articles/carcinogen.pdf., 2018.

[L23] Pitkänen M. Emotions as sensory percepts about the state of magnetic body? Available at: https://tgdtheory.fi/public_html/articles/emotions.pdf., 2018.

[L24] Pitkänen M. Expanding Earth hypothesis, Platonic solids, and plate tectonics as a symplectic flow. Available at: https://tgdtheory.fi/public_html/articles/platoplate.pdf., 2018.

[L25] Pitkänen M. Expanding Earth Model and Pre-Cambrian Evolution of Continents, Climate, and Life. Available at: https://tgdtheory.fi/public_html/articles/expearth.pdf., 2018.

[L26] Pitkänen M. Is the hierarchy of Planck constants behind the reported variation of Newton's constant? Available at: https://tgdtheory.fi/public_html/articles/variableG.pdf., 2018.

[L27] Pitkänen M. New results in the model of bio-harmony. Available at: https://tgdtheory.fi/public_html/articles/harmonynew.pdf., 2018.

[L28] Pitkänen M. New support for the view about Cambrian explosion being caused by rapid increase of Earth radius. Available at: https://tgdtheory.fi/public_html/articles/HIFs.pdf., 2018.

[L29] Pitkänen M. TGD view about quasars. Available at: https://tgdtheory.fi/public_html/articles/meco.pdf., 2018.

[L30] Pitkänen M. An overall view about models of genetic code and bio-harmony. Available at: https://tgdtheory.fi/public_html/articles/gcharm.pdf., 2019.

[L31] Pitkänen M. Could 160 minute oscillation affecting Galaxies and the Solar System correspond to cosmic "alpha rhythm"? Available at: https://tgdtheory.fi/public_html/articles/cosmoalpha.pdf., 2019.

[L32] Pitkänen M. Earhquakes and volcanic eruptions as macroscopic quantum jumps in zero energy ontology. Available at: https://tgdtheory.fi/public_html/articles/earthquakes.pdf., 2019.

[L33] Pitkänen M. New results related to $M^8 - H$ duality. Available at: https://tgdtheory.fi/public_html/articles/M8Hduality.pdf., 2019.

[L34] Pitkänen M. Quantum self-organization by h_{eff} changing phase transitions. Available at: https://tgdtheory.fi/public_html/articles/heffselforg.pdf., 2019.

[L35] Pitkänen M. Some comments related to Zero Energy Ontology (ZEO). Available at: https://tgdtheory.fi/public_html/articles/zeoquestions.pdf., 2019.

[L36] Pitkänen M. Three findings about memory recall and TGD based view about memory retrieval. Available at: https://tgdtheory.fi/public_html/articles/memoryrecall.pdf., 2019.

[L37] Pitkänen M. Waterbridge experiment from TGD point of view. Available at: https://tgdtheory.fi/public_html/articles/waterbridge.pdf., 2019.

[L38] Pitkänen M. Can TGD predict the value of Newton's constant? Available at: https://tgdtheory.fi/public_html/articles/Gagain.pdf., 2020.

[L39] Pitkänen M. Could brain be represented as a hyperbolic geometry? Available at: https://tgdtheory.fi/public_html/articles/hyperbolicbrain.pdf., 2020.

[L40] Pitkänen M. Could quantum randomness have something to do with classical chaos? Available at: https://tgdtheory.fi/public_html/articles/chaostgd.pdf., 2020.

[L41] Pitkänen M. New results about dark DNA inspired by the model for remote DNA replication. Available at: https://tgdtheory.fi/public_html/articles/darkdnanew.pdf., 2020.

[L42] Pitkänen M. Still about quantum measurement theory in ZEO. Available at: https://tgdtheory.fi/public_html/articles/qmeasuretgd.pdf., 2020.

[L43] Pitkänen M. The dynamics of SSFRs as quantum measurement cascades in the group algebra of Galois group. Available at: https://tgdtheory.fi/public_html/articles/SSFRGalois.pdf., 2020.

[L44] Pitkänen M. Time reversal and the anomalies of rotating magnetic systems. Available at: https://tgdtheory.fi/public_html/articles/freereverse.pdf., 2021.