

# Allais effect again

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## Contents

### Abstract

The Allais effect was first reported by Maurice Allais in 1954. It involves an abrupt change in the azimuth of a paraconical pendulum's oscillation plane during the solar eclipse, totaling up to 13.5 degrees. There is also a reduction of the oscillation frequency several orders of magnitude larger than the Newtonian prediction. The amplitude of the oscillation fluctuates in the transition to the solar eclipse.

In this article, the earlier model for the effect based on the replacement of the oscillator with its quantum counterpart with very large gravitational Planck constant is discussed. For  $\hbar_{gr}$  the oscillator corresponds to a small oscillation quantum number limit, and this can give rise to large quantum fluctuations of the amplitude as transitions which change this quantum number so that the reason would not be gravitation but TGD based quantum theory.

There is evidence that Allais effect does not involve screening. This leads to ask whether a diffractive effect is involved. The most promising model relies on quantum diffraction in the "world of classical worlds" (WCW) consisting of space-time surfaces obeying holography = holomorphy principle and having interpretation as Bohr orbits. Monopole flux tubes can be also interpreted as analogs for flowlines of an incompressible hydrodynamic flow past an obstacle. They can be regarded as quantum particles meaning analogy with quantum diffraction for Schrödinger equation.

In the general relativistic framework, the maximal value for the reduction  $r = \Delta f/f \simeq 2^{-11}$  of the oscillator frequency is huge.  $r$  is the velocity parameter appearing in the expression of the solar gravitational Planck constant and is near to the electron-proton mass ratio  $m_e/mp$ . Which option is correct?

The pondering of this question led as a by-product to a solution of a longstanding problem concerning the interpretation of the velocity parameter  $\beta_0$  appearing in the Notale's hypothesis. Field equations allow as solutions warped space-time surfaces, which are flat just like Minkowski space but have reduced light velocity  $c_{\#} < c$ . The identification  $\beta_0 = c_{\#}$  is natural. Warping as a universal quantum critical phenomenon distinguishing between TGD and GRT, allows to identify a mechanism for the fluctuations of the oscillator frequency in the Allais effect:  $\Delta f/f \sim m_e/mp$  would be the correct interpretation for the maximal reduction of frequency. Also a possible explanation for the variation of measured Newton's constant and variation of the length of the day emerges in terms of the radiation pressure created by dark gravitons.

The warping only shifts the gravitational potential appearing in  $g_{tt} = 1 - \Phi_{gr}$  but the classical gravitational force is unaffected. The reduction of the light velocity caused by the warping resembles that appearing for dielectrics and suggests that the shadow of the Moon involves the reduction  $c \rightarrow c_{\#}$ . The large value of  $\hbar_{gr}$  and  $c_{\#} < c$  suggest that the reflection, refraction and also diffraction of dark gravitons from the pendulum could cause the transversal effects in the transition zones. The pendulum would become a gravitational wave detector. The essential element would be the frequency-/ wavelength resonance due to the fact that the gravitationally dark gravitons emitted by the Sun in the energy range 1 eV- $10^5$  eV have the same wavelength equal to the gravitational Compton length.

To sum up, the Allais effect would not reflect so much gravitational interaction as the basic ontology of TGD involving WCW, hierarchy of Planck constants, and zero energy ontology as quantum ontology.

## 1 Introduction

The Allais effect [E1, E10] (see this and this) was first reported by Maurice Allais in 1954. It involves an abrupt change in the azimuth of a paraconical pendulum's oscillation plane during the solar eclipse, totaling up to 13.5 degrees.

### 1.1 Empirical findings

Consider first a brief summary of the findings of Allais and others [E10].

1. Paraconical pendulum consists of a rigid rod of  $\sim 1$  meter and a metal ball. The bob, that is the weight at the bottom, has lense like shape. Paraconical pendulum differs from the conical pendulum in that the suspension point of the pendulum is not fixed but is a metal

sphere able to roll without sliding in plane. Therefore it has 2 degrees of freedom rather than only one: both swinging and rotation around the vertical axis are possible.

2. In the absence of any other forces than the gravitation of Earth) paraconical pendulum can behave much like a conical or Foucault pendulum. The oscillation plane of the paraconical pendulum turned by 13,5 degrees during 14 minutes (see this). It is difficult to see how the gravitational fields of the Sun and Moon could explain this behaviour by changing the effective value of the Earth's gravitational acceleration.
3. Allais concludes from his experimental studies that the orbital plane approach always asymptotically to a limiting plane and the effect is only particularly spectacular during the eclipse. During solar eclipse the limiting plane contains the line connecting Earth, Moon, and Sun. Allais explains this in terms of what he calls the anisotropy of space.
4. Some experiments carried out during eclipse have reproduced the findings of Allais, some experiments not. In the experiment carried out by Jeverdan and collaborators in Romania it was found that the period of oscillation of the pendulum decreases by  $\Delta f/f \simeq 5 \times 10^{-4}$  [E1, E9] which happens to correspond to the constant  $\beta_0 = 2^{-11}$  appearing in the formula of the gravitational Planck constant for the Sun. It must be however emphasized that the overall magnitude of  $\Delta f/f$  varies by five orders of magnitude. Even the sign of  $\Delta f/f$  varies from experiment to experiment.
5. There is also the finding by Popescu and Olenici, which they interpret as a quantization of the plane of oscillation of paraconical pendulum during solar eclipse [E11].
6. There is also evidence that the effect is present also before and after the full eclipse. The time scale is 1 hour. Allais emphasized that the effect is a dynamic, not static, phenomenon, connected to the variation of weight or inertia in the space swept by the pendulum during the eclipse. The 10% excessive bending of light is reported during some eclipses (the "residual arc").

While many attempts to confirm it have met with varied or ambiguous results, several observations indicated anomalous behavior that cannot be easily explained by general relativity (GR) or standard Newtonian mechanics.

## 1.2 Anomalies and their brief explanations

Allais effect raises several problems which do not seem to have answers in the Newtonian and Einsteinian frameworks. The key observations are as follows.

1. Allais effect does not seem to involve any modification of classical gravitation in the sense that a modification of the classical gravitational force is not involved. This allows modification of gravitational potential by an addition of constant and in general relativity the addition of constant to the expression of the time component of the space-time metric.
2. The effect seems to be due to a horizontal force. The orbital plane is changed abruptly, which suggests a new kind of force. If is gravitational, it could be a force caused by the scattering of gravitons from the pendulum. The huge value of gravitational Planck constant implying long length scale quantum coherence and possibility of Bose-Einstein condensates together with the independence of the gravitational Compton length of graviton energy could make this effect large.
3. The fluctuations during the transition are large. This suggests quantum criticality. Classical field equations allow warped space-time surfaces, which are gravitational and gauge vacua and have a flat Minkowski metric with a reduced light-velocity  $c_{\#} = \sqrt{1 - R^2\omega^2}$ .

This leads to the notion of twisted (or warped) Hamilton-Jacobi structure [L11, L2] for which canonically embedded  $M^4$  is tilted toward  $M^4 \times S^1 \subset H$ : this allows the generalization of warping to the case of general space-time surfaces as solutions of field equations obeying holography = holomorphy principle [L3, L7].

A thin metal plate serves as an excellent analogy and is a critical system. Same is true for the deformations of canonically embedded  $M^4$ . This universal criticality reflecting itself as fluctuations of  $c_{\#}$  could be behind very many forms of quantum criticality.

4. Gravitational Planck constant is expected to play a key role in the Allais effect. It is inversely proportional to a velocity parameter  $\beta_0$ . The identification of  $\beta_0$  has remained a mystery. The identification  $\beta_0 = c_{\#}$  is highly suggestive. This implies that one can talk about reflection, and refraction of waves at the boundaries of two regions with different values of  $\beta_0$ .
5. There are also diffractive effects and also these could be understood if gravitational waves or gravitations cause the transversal effects on the pendulum. Gravitational waves are indeed transversal. The gravitational Compton length  $\Lambda_{gr} = GM/\beta_0$  is the same for all gravitons and would characterize the diffraction pattern. Irrespective of the energy of the gravitons (or of any particle). There are several alternative identifications of the large mass  $M$  and the value of  $\beta_0$ . Empirical findings suggest a wavelength of 44 m and this scale can be understood rather naturally.
6. By a dimensional argument, the force constant of the gravitational pendulum is proportional to  $c_{\#} < c$ . The fluctuations of  $c_{\#} < c$  could induce the fluctuations of the pendulum's oscillation frequency. A possible quantum phase transition explaining the upper bound for  $\Delta f/f \leq 2^{-11} \simeq m_e/m_p$  can be identified.

### 1.2.1 Does gravitational pendulum behave as a harmonic oscillator at small quantum number limit?

In this article, the earlier model for the effect based on the replacement of the oscillator with its quantum counterpart with very large gravitational Planck constant is discussed. For  $\hbar_{gr}$  the oscillator corresponds to a small oscillator quantum number limit, and this can give rise to large quantum fluctuations of the amplitude as transitions which change this quantum number so that the reason would not be classical gravitation but TGD based quantum theory allowing large quantum gravitational effects.

### 1.2.2 Are reflection, refraction and diffraction of gravitational waves responsible for the Allais effect?

There is evidence that the Allais effect does not involve screening of classical gravitational force. This raises the question whether reflection, refraction and diffraction type effects assignable to gravitational waves or gravitons are involved and explain the transversality of the effect.

Also diffractive effects are involved and conform with the long wavelengths implied by  $\hbar_{gr}$ . A rather promising model relies on quantum diffraction in the "world of classical worlds" (WCW) consisting of space-time surfaces obeying holography = holomorphy principle and having interpretation as Bohr orbits. Monopole flux tubes can be also interpreted as analogs for flowlines of an incompressible hydrodynamic flow past an obstacle. They can be regarded as quantum particles meaning analogy with quantum diffraction for Schrödinger equation.

### 1.2.3 The velocity parameter of the gravitational Planck constant as reduced light velocity induced by warping

The pondering of this question led as a by-product to a solution of a longstanding problem concerning the interpretation of the velocity parameter  $\beta_0$  appearing in the Notale's hypothesis. Field equations allow as solutions warped space-time surfaces, which are flat just like Minkowski space but have reduced light velocity  $c_{\#} = \sqrt{g_{tt}} = \sqrt{1 - R^2\omega^2} < c$ . The identification  $\beta_0 = c_{\#}$  is natural. This motivates the notion of twisted (or warped) Hamilton-Jacobi structure allowing to generalize this phenomenon to non-vacuum extremals. Warping as a universal quantum critical phenomenon distinguishing between TGD and GRT, makes it possible to identify a mechanism for the fluctuations of the oscillator frequency in the Allais effect.

The warping only shifts the gravitational potential appearing in  $g_{tt} = 1 - 2\Phi_{gr}$  but the classical gravitational force is unaffected. The reduction of the light velocity caused by the warping resembles that appearing for dielectrics and suggests that the shadow of the Moon involves

the reduction  $c \rightarrow c_{\#}$ . The large value of  $\hbar_{gr}$  and  $c_{\#} < c$  suggest that the reflection, refraction and also diffraction of dark gravitons from the pendulum could cause the transversal effects in the transition zones.

The shadow of the Moon would be analogous to a dielectric. This would imply reflection and refraction of dark gravitational radiation from the Sun. Reflection at the surface of the Earth would induce transversal gravitational force amplified by the huge value of gravitational Planck constant and by the fact that the gravitational Compton length for gravitons does not depend on the energy of the dark graviton. The pendulum would become an ideal detector of gravitons. The 10% excessive bending of light is reported during some eclipses (the "residual arc") could be interpreted in terms of reflection for dark photons by the same mechanism.

#### 1.2.4 The reason for huge size of the effect: dark gravitational radiation has always the same wavelength

Sun produces gravitational radiation in the energy range  $(1 - 10^5)$  eV. The huge value of  $\hbar_{gr}$  scales the wavelength range and makes possible long scale quantum coherence at the gravitational magnetic body amplifying the effect.

Gravitational Planck constant for a massless particle with energy  $E$  is  $GME/\beta_0$ . By Equivalence Principle, the expression for the wavelength of the graviton is  $\lambda = \Lambda_{gr} = GM/\beta_0 = r_S/2\beta_0$  irrespective of graviton energy. All dark gravitons, in fact all dark particles, would have the same Compton wavelength! This could explain why the Allais effect is so huge. The gravitational pendulum could become a detector of gravitons.

For the Earth mass  $M = M_E$  and for  $\beta_{0,E} \simeq 1$  this gives 5 mm. The replacement  $\beta_{0,E} \rightarrow \beta_{0,S} \simeq 2^{-11}$  assigned with the Sun would give  $\lambda = 10$  m to be compared with 44 m suggested by the experiments.  $\beta_0 = 2^{-13}$  would give a good fit. For  $M = M_{Sun} = 3 \times 10^5 M_E$  one has  $\lambda = \Lambda_{gr,S} = 3 \times 10^6$  m  $\simeq R_E/2$ , which is solar gravitational Compton length characterizing Sunspot size scale.

#### 1.2.5 Reduction of the oscillator frequency

From the point of view of General Relativity, the maximal value for the reduction  $r = \Delta f/f \simeq 2^{-11}$  of the oscillator frequency is huge. The identification of the fluctuations as being due to the fluctuations of  $\beta_0 = c_{\#}$  is natural.

There are several intriguing co-incidences.  $r$  equals the velocity parameter  $\beta_0$  appearing in the expression of the solar gravitational Planck constant and is also near to the electron-proton mass ratio  $m_e/mp$ . Also the velocity of the solar system with respect to the galactic center is of this order of magnitude? Which option is nearer to the truth?

$\Delta f/f \leq m_e/mp$  could be nearest to the correct interpretation for the maximal reduction of frequency. The mechanism could be the phase transition in which Rydberg atoms with very large size at the magnetic body decay to protons and electrons. The condition that  $\hbar_{gr}(H) = \hbar_{gr}(p)$  guarantees that H atoms and protons can reside in the same monopole flux tubes: this condition holds true in biology also for base pairs of DNA. This would give  $\beta_0(H)/\beta_0(p) = c_{\#}(H)/c_{\#}(p) = m_p/m_H$ . The values of  $\Delta f/f \leq m_e/mp$  could mean that only a part of the H atoms decay to a proton and electron.

The cautious conclusion would be that the Allais effect does not tell so much about classical gravitational physics than about the new quantum ontology predicting the notion of WCW realizing holography = holomorphy vision, the hierarchy of Planck constants, in particular huge values of gravitational Planck constant, and ZEO. The warping phenomenon distinguishing between General Relativity and TGD would be the central element.

The cautious conclusion would be that the Allais effect does not tell so much about new gravitational physics than about the new quantum ontology predicting the notion of WCW realizing holography = holomorphy vision, the hierarchy of Planck constants, and ZEO. The warping phenomenon distinguishing between General Relativity and TGD would be the central element.

## 2 The TGD view of the Allais effect

The questions of Esa Ruoho refreshed my interest in the Allais effect. Appendix gives a brief summary of the basic assumptions and implications of TGD necessary for the understanding of the TGD view of the Allais effect. The view of TGD as it was 2024 can be found in [L5, L6].

### 2.1 General considerations

It is good to start with general considerations.

#### 2.1.1 Is classical gravitational physics enough?

The conservative option is that the Allais effect can be understood in terms of classical forces. Second option is that the effect involves quantum mechanics, even the TGD version of it, in an essential manner.

Consider first the classical forces possibly involved.

1. Newtonian gravity of the Earth, Moon and Sun is characterized by gravitational potentials. Each of these produces a gradient force. During an eclipse of the longitudinal effect, the Sun's gravitational force could weaken during a total eclipse if a partial screening occurs. If the classical  $Z^0$  force of Kähler force is involved, it could interfere with the gravitational force and contribute to the effect.

The change of the gravitational force in vertical direction is reported to be consistent Newtonian predictions. One should understand why the effect is large in the transversal directions. The Sun-Moon pair and the Earth's vertical are in different directions. What is the direction of the Sun relative to the Earth's gravitational field in the studied cases? The shadowing effect depends on this direction.

2. Could the gravitomagnetism predicted by general relativity play a role? In the Maxwellian approximation, the gravitomagnetic field of the Sun is extremely weak: there are however anomalies, which challenge this assumption [E14, E5, E6] but might have different explanation in the TGD framework.
3. In the TGD framework, electroweak magnetism associated with induced classical  $Z^0$  or Kähler field could be involved. For  $\hbar_{gr}$  these fields could be important, at least in the scale  $\Lambda_{gr} = GM/\beta_0 = r_S/2\beta_0$ , which for the Sun is about  $R_E/2$  and for the Earth about 5 mm. In the TGD picture, monopole flux tubes carrying Kähler monopole fluxes could give rise to a Lorentz force. Could this relate to the transversality of the Allais effect?

What do the flux tubes related to electroweak magnetism or gravito-magnetism look like? The proposal is that gravitational interaction is mediated by narrow square-like radial monopole loops with a magnetic field parallel to the flux tube.

Two standard physics views can be considered.

1. In the first case, there is no shadowing of gravitation by the Moon and the effects of the Sun and the Moon are additive.
2. In the second case, the Moon partially shadows the Sun and only the Moon would contribute to the gravitational force during complete shadowing. This does not conform with the belief that gravitational interaction is not screened.

It is difficult to see how either of these pictures could explain the Allais effect unless one brings in something totally new. These could be dark gravitons with gigantic gravitational Planck constant. Their scattering could have large effects. There is evidence for diffraction which suggests that gravitational waves are involved. The transversality of the effects indeed conforms with that of gravitational waves.

### 2.1.2 Is TGD based quantum theory necessary?

It seems that gravitational waves are needed to explain diffractive effects. The problem is that an extremely weak effect is in question. Could the scattering of dark gravitons from the pendulum be involved? Could the huge value of  $h_{gr}$  characterizing large scale quantum coherence making possible analogs of Bose-Einstein condensates amplify the interaction of gravitational waves with the pendulum?

Could the effect be proportional to square  $N^2$  of the number of flux tubes meeting the pendulum rather than  $N$  in the quantum coherence region? Or are the energies of the gravitons (say) as  $E = h_{gr}f$  much larger than for the ordinary Planck constant and therefore amplify the effect? A possible interpretation for the large value of  $h_{gr}$  is as the replacement of a single flux tube with a bundle of  $n = h_{gr}/h$  flux tubes defining an analog of Bose-Einstein condensate. For this interpretation the two alternatives might be equivalent.

A further important point is that the gravitational Compton length of any particle is independent of its mass or energy. This could amplify the interactions dramatically.

### 2.1.3 Geometric optics is not enough: diffraction is needed

The Allais effect occurs during the entire period that it takes for a full shadow to travel over the Earth and also in the region where the full shadow is not present and the effects measured at different loci correlate [E12]. Therefore the effect of the Moon is not local like in the geometric optics picture and diffractive effects are suggestive.

1. A hole in the screen generates a characteristic diffraction pattern (see ) expressible in terms of a Bessel function, whose argument is proportional to the ratio  $R/\lambda$  of the radius  $R$  hole and the wavelength  $\lambda$  of the incoming light.
2. Assuming linearity of the underlying field equations, the Moon could be formally regarded as an "antihole". If a wave falls on a screen, a diffraction pattern is created. When a hole in the screen is replaced with an obstacle such as Moon, this pattern must be subtracted from the pattern in the absence of the hole.

What is diffracted?

1. Could classical waves be gravitational waves or possibly classical  $Z^0$  waves generated by the Sun? In the general relativity framework, gravitational waves from the Sun are predicted to be extremely weak. Could the diffracting waves correspond to  $Z^0$  cyclotron radiation generated at the flux tubes carrying dark electrons?

Since the classical  $Z^0$  field must be weaker than the gravitational field, also this option looks implausible unless constructive interference due to the long range quantum coherence is in question. The large value of  $h_{gr}$  would give them a large amount of energy in the energy scale of visible light. However, the very idea of large  $h_{eff}$  is that lowest order contribution given as a classical contribution having no dependence on  $h_{eff}$  dominates.

2. Could a diffraction analogous to the diffraction of quantum particles identified as flux tubes emanating from the Sun be in question? The flux tubes as analogs of strings would be analogs of quantum particles and would be described by an analog of Schrödinger amplitude identifiable as a spinor field in the "world of classical worlds" (WCW) consisting of space-time surfaces satisfying holography= holomorphy principle.

The flux tubes arriving from the Sun would be like a beam of particles described by a wave function and interference and diffraction for wave functions would take place. Moon could act as an obstacle producing the opposite of the effect produced by a hole in the screen. The effect has little to do with classical or quantum gravitational fields.

### 2.1.4 TGD options

TGD allows two options.

1. In TGD inspired phenomenology, gravitational interactions would be mediated by the monopole flux tubes which are 3-D generalizations of strings but can have an astrophysical length scale. The gravitational flux proportional to the monopole flux would be analogous to an incompressible fluid flow and the Moon could act as an obstacle. The gravitational flux would not be lost but would go past the Moon.

Contact between the pendulum and the flux tubes would occur. Wormhole contacts define contacts and also the 2-D string world sheets as intersections of the space-time sheets are involved.

2. TGD also allows a purely quantal view based on quantum variants of reflection, refraction and diffraction in WCW. Monopole flux tubes would be analogous to quantum particles and the Moon would serve as an obstacle inducing quantum diffraction in the same way as in double slit experiment. The absence of screening would correspond to unitarity and probability conservation. This obstacle could be also partially transparent meaning reflection and refraction.

### 2.1.5 Monopole flux tubes as mediators of the gravitational and other interactions

TGD suggests that monopole flux tubes serve as mediators of gravitational and also other interactions.

1. Magnetic monopole flux tubes are thickened strings but their lengths can be astrophysical and they carry a conserved monopole flux. This means a connection with string models. The difference is however that the flux tubes as string like objects could have astrophysical length scales. Could one regard flux tubes as particles and assign to them wave function as WCW spinor field so that one would have quantum diffraction at the level of WCW?
2. Interesting questions relate to the possible role of reconnections possible for the flux tubes returning to the Sun. The conservation of monopole flux allows U-shaped flux tubes turning back at the Moon and returning to the Sun. This would be an analog of reflection. But doesn't this mean that these flux tubes cause no long range gravitational effect in this case? Also reconnections creating closed flux tubes propagating past the Moon are possible but can they contribute to the static part of the gravitational force?

Can one make any guesses about the dimensions of the monopole flux tubes? The proposal of [E12] is that the Sun is emitting particles with  $\lambda \sim 44$  m spatial periodicity. Could these particles correspond to monopole flux tubes? Could one think that flux tubes from the are emitted as flux tube bundles of radius which corresponds to the quantum gravitational coherence scale  $\Lambda_{gr}(S) \simeq 3000$  km  $\sim R_E/2$  of the Sun. Could the separation between these flux tubes be  $\lambda \sim 44$  m? If so, a single flux tube bundle would contain  $N \sim (\Lambda_{gr}/\lambda)^2 \simeq .68 \times 10^{10}$  flux tubes.

### 2.1.6 How to model the effects of the Moon?

One can consider several models for the effects of the Moon.

1. The first option is screening so that the Moon would absorb the gravitational flux tubes or force them to turn backwards. This does not conform with the Newtonian view of gravitation nor with the conservation of gravitational flux which would correspond to the monopole flux. Also the findings about the presence of Allais effect also outside the eclipse region are in conflict with this idea and suggest diffraction-like effects. This suggests that gravitational waves are involved besides the gravitational potential.
2. Could the situation correspond to an incompressible hydrodynamic flow past an obstacle? The gravitational flux tubes would be analogous to hydrodynamical flow lines. The incompressibility of the flow would correspond to the conservation of the magnetic and gravitational flux. This would give effective screening behind the Moon but conservation of flux would force the flux past the Moon. Since classical gravitational force is not modified appreciably, a more realistic option is that partial reflection and refraction occurs.

3. One could try to describe the situation as reflection, refraction and diffraction of classical gravitational and  $Z^0$  fields. In this case the Moon would serve as an "anti-source" generating the negative of the diffraction pattern generated by a hole in the screen. If the fields are identified as magnetic fields quantized to flux tubes in TGD, the flux conservation is obtained and there is an analogy with hydrodynamics of incompressible fluid. The object could be reflective and partially transparent.
4. A further, and perhaps the most realistic, view is in terms of quantum diffraction from a partially transparent object at the level of the WCW for the monopole flux tubes as basic objects as 3-surfaces generalizing the point-like particles. The WCW spinor field would correspond to the analog of Schrödinger amplitude. Also WCE counterparts of reflection and refraction would occur.

**2.1.7 Could the induced  $Z^0$  and Kähler fields have a role in the Allais effect?**

The interpretation of Allais effect in large scales in terms of diffraction in WCW is rather attractive but one can also consider the possibility that the diffraction of gravitational and  $Z^0$  fields is involved and perhaps even provide an alternative description. This also relates to the fundamental description of quantum gravitation. Quantization of metric does not work in general relativity: could the description of quantum gravitation be in terms of WCW spinor fields having as arguments Bohr orbit like space-time surfaces rather than of the second quantized metric tensor.

1. TGD predicts the possibility of long range  $Z^0$ /Kähler forces and I have also considered classical  $Z^0$  force as a source of the Allais effect [K4]. Both electromagnetic and  $Z^0$  field involve Kähler field as a part and the latter could be a long range field which is not subject to the weak screening.
2. Could  $Z^0$  eclipse give a non-gravitational contribution to the Allais effect?.  $Z^0$  field and maybe also classical  $W$  fields would be massless below  $\Lambda_{gr}$  due to the large value of  $h_{gr}$ .  $Z^0$  Coulombic force directed along the flux tubes would be screened and also a  $Z_0$  magnetic torque would be present. One could say that besides em radiation also  $Z^0$  readiation represented as waves from the Sun is screened.

**2.2 The model of gravitational pendulum as quantum harmonic oscillator with gravitational Planck constant**

It is natural to simplify the situation by considering a conical pendulum, that is gravitational pendulum for which the oscillation plane is free, instead of the paraconical pendulum.

To build a qualitative view, one can model the gravitational pendulum idealized as a harmonic oscillator. If  $h_{gr}$  is important then one must build a quantum model for the oscillator. One could first consider the simplest gravitational pendulum with one angle as a degree of freedom so that no attempt is made to explain the change in the oscillation plane. A more realistic case would be as a conical pendulum with two degrees of freedom corresponding to swinging and rotation.

One can start from a harmonic oscillator model for the conical pendulum.

1. For a harmonic oscillator, the frequency is independent of the amplitude of the oscillation and one has  $E = n\hbar\omega$  in the standard quantum mechanics. At the limit of large values of oscillator number  $n$ , the system behaves classically. The replacement  $\hbar \rightarrow \hbar_{gr}$  implies  $E = n\hbar_{gr}\omega$ . This can lead to a situation in which the value of  $n_{gr}$  is small. This can lead to large effects as the value of  $n_{gr}$  changes.
2. What is the situation for a non-linear oscillator such as a gravitational pendulum? In this case the frequency depends on amplitude classically. In the quantum case the frequency could be identified in terms of the eigenvalues of energy as  $\omega = E/\hbar$ . The energy eigenvalues are however expected to depend on  $\hbar$ . Hydrogen atoms are a good example: in this case the energy eigenvalues are proportional to  $\alpha_{em}^2$  and therefore to  $1/\hbar^2$ .
3. Can one imagine that the scaling  $\hbar \rightarrow \hbar_{gr}$  could lead during the eclipse to a reduction of  $f$ , which is by 3 orders of magnitude larger than predicted by the classical model? For the

classical oscillator the reduction of frequency is at maximum about 14 per cent. The classical amplitude of the oscillator relates by quantum-classical correspondence to the oscillator number  $n$  as  $A \propto \sqrt{n}$ .

Very large value of  $\hbar_{eff}$  reduces the value of  $n$  to  $n_{gr} = (\hbar/\hbar_{gr})n$  and it can become small. Amplitude would be by  $(\hbar/\hbar_{gr})^{1/2}$ . Does this mean that the harmonic oscillator approximation should improve? If so, even the non-linear quantum model is unable to explain the large reduction of  $f$ .

Oscillator quantum number as an analog for the number of quanta and oscillator amplitudes are canonically conjugate variables and Uncertainty Principle states that if the amplitude is precisely defined, the value of  $n$  is uncertain.

Could the large value of  $\hbar_{gr}$  make the oscillator genuinely quantal?

1. It is good to take the values of  $\hbar_{gr}$  for proton as a standard example. For the general mass  $m = Nm_p$  one has  $\hbar_{gr}(M, m) = N\hbar_{gr}(M, m_p)$ . For  $N = 1$  one has  $\hbar_{gr}(M_E, m_p) = GM_E m_p / \beta_0 = r_s / 2L_p \simeq 2.377 \times 10^{13}$ . For the Sun one has  $\hbar_{gr}(M_S, m_p) = GM_S m_p / 2\beta_0 = r_s 2^{11} / 2L_p \simeq 1.426 \times 10^{22}$ .
2. The energy of the classical oscillator is  $E_{cl} = m\omega^2 A^2 / 2$ . Quantum-classical correspondence  $E_{cl} = E_{qu} = n\hbar\omega$  gives the estimate  $n = mAR^1\omega / 2\hbar$ , with  $\hbar = 1.054 \times 10^{-34}$  J. One can consider a simple numerical example. Assume  $\omega = 2\pi$  s<sup>-1</sup>, mass  $m = 1$  kg and amplitude  $A = 1$  m. In this case one obtains  $n \simeq .47 \times 10^{34}$ .
3. Assume that the oscillator has a size of quantum coherence region with radius  $\Lambda_{gr}(E) = r_S(E)/2 \simeq .5$  cm for  $\beta_0(E) \simeq 1$ . Suppose that a cube sized region with this size has the density of water  $\rho \sim 10^{30} m_p / m^3$ . In this case one would have  $N \sim 1.25 \times 10^{23}$ .  
This gives  $n/n_{gr}(E) = 2.3 \times 10^{36}$ . Using the estimate for  $n$  this gives  $n_{gr}(E) = n/2.31 \times 10^{36} \sim .21 \times 10^{-2}$ . This does not make sense since  $n_{gr}(E)$  should be larger than 1. The volume should be larger by at least by a factor of about 500. The size of the quantum coherence regions should be at least 5 cm, 10 times larger.
4. Assume that the oscillator has a mass of 1 kg and has in the case of water density a volume of  $10^{-3}$  m<sup>3</sup>. One can argue that  $\Lambda_{gr}(E)$  gives only a lower bound to the size of the quantum coherence region. If the scale up volume corresponds to a gravitational quantum coherence region, the size would be 10 cm so that  $n_{gr}$  would be equal to 17.6 and larger than 1.
5. In the case of the Sun the estimate gives  $n/n_{gr} = 7.7 \times 10^{44}$ . This is by factor  $(3.3 \times 10^8)$  larger than for the Earth and the problem becomes even worse. The scaling of about factor  $10^3$  for the size of the quantum coherence region to about 100 m would be required.

The size scale of the quantum coherence region in the solar gravitational field is  $R_E/2$  and in this case one would have the limit with a large value of  $n_{gr}$ : this situation cannot of course correspond to the recent case.

Diffraction is characterized by two scales: the radius  $R$  of the hole in the screen (the radius of the obstacle in the dual situation) and the wavelength  $\lambda$  of the diffracting wave.

1. The natural identification for  $R$  is as the radius of the Moon.
2. The wavelength is for gravitational Planck constant independent of energy and given by gravitational Compton length  $\Lambda_{gr} = GM/\beta_0 = r_s/2\beta_0$ .

The parameters  $R$  and  $\lambda$  should have meaning at the level of both space-time surface and WCW.

What happens during an eclipse if the reflection, refraction and diffraction play a role? One must distinguish between short and long wavelengths.

1. Concerning short wavelengths, it could be imagined that the contribution from the Sun is partially screened by reflection during the eclipse. For short wavelengths there would be no diffraction during the total eclipse and geometric optics would work. This would mean description in terms of reflection and refraction. Reflection would give rise to partial screening. For the Earth for on has  $\Lambda_{gr} = 5 \text{ mm}$   $\beta_{0,E} = 1$  (the size scale of snowflake) and  $\Lambda_{gr} = 10 \text{ m}$  for  $\beta_{0,E} = 2^{-11}$ .
2. For the Sun, large value of the gravitational Planck constants  $h_{gr}$  implies a long gravitational Compton wavelength of order  $R_E/2$  for  $\beta_0(Sun) \simeq 2^{-11}$  and  $R_E/2$  for  $\beta_0(Sun) \simeq 2^{-11}$  and 1.5 km for  $\beta_0 = 1$ . This would indicate that diffraction and interference are important for long wavelengths. An analogy is, for example, the interference pattern that occurs around a boat dock in waves.

### 3 Warping as an explanation for the reduction of the pendulum's oscillation frequency

The attempt to understand the reduction of the pendulum's oscillation frequency led to a solution of another long standing problem related to the understanding the physical meaning of the parameter  $\beta_0$  appearing in the formula for the gravitational and electric Planck constants. The solution came from the notion of warping discovered already during the first year of TGD about 48 years ago and distinguishing between General Relativity and TGD. In the following I discuss two approaches. The first approach is based on the frequency reduction as an analog of redshift. The problem is that  $\beta_0$  cannot be interpreted as a for the motion of matter. Second approach is based on the warped space-time surfaces inducing non-gravitational redshift which cannot be assigned to the motion of matter.

#### 3.1 The reduction of the frequency of the pendulum as evidence for ZEO?

The reduction of the oscillator frequency is 3 orders of magnitude too large. It corresponds also to the parameter  $\beta_0(S)$  appearing in  $\hbar_{gr}(S)$ . Suppose that  $\Delta f/f \simeq \beta_0(S) \simeq 2^{-11}$  is not an accident. Could  $\beta_0$  correspond to a real velocity?

1. Intriguingly, the formula for redshift for this velocity gives in  $\Delta f/f = \sqrt{(1 - \beta_0)/(1 + \beta_0)} \simeq -\beta_0$ . Could it be that the oscillation frequency is in some sense redshifted during the eclipse. The magnitude of  $v_0 = c\beta_0 \simeq 150 \text{ km/s}$  is huge as compared to the velocity of the oscillator having order of magnitude 1 m/s. Therefore the redshift cannot be caused by a real motion of the pendulum relative to the observer.
2. Could one imagine any physical interpretation for  $\beta_0(S)$ ? The solar system rotates around the galactic center with a velocity of 200–230 km/s. Could  $\beta_0(S)$  relate to this velocity? Note that Earth moves relative to the Sun with velocity 29.78 km/s.

What comes to mind as an explanation for  $\Delta f/f$  in the TGD framework is zero energy ontology (ZEO) already briefly summarized.

1. Could the possible partial screening of the possible wave part of the solar gravitational field by reflection by the Moon mean that  $cd(S)$ , the solar CD as a candidate for the  $cd$  of the observer, separate from the  $cd(P)$ , the CD of the pendulum as sub-CD of  $cd(S)$ ? The splitting of the U-shaped monopole flux tube contacts coming from the Sun by a reconnection as a correlate for the reflection by the Moon could correspond to this splitting at the space-time level.
2. Quantum criticality is expected to prevail in the beginning of the solar eclipse. Large length scale fluctuations should take place. Could the large fluctuations observed in the beginning and end of the eclipse correspond to fluctuations of  $\hbar_{gr}$  and thus in the values of the velocity parameter  $\beta_0$  as a moduli parameter for CD?

The causal diamond  $cd(P)$ , associated with the quantum coherence region  $U$  of the pendulum, is a sub- $cd$  of  $cd(Sun)$ . Could the velocity parameter  $\beta_0$  appearing in  $\hbar_{gr}$  parameterize a Lorentz boost for  $cd$  relating it to a standard  $cd$ . A possible problem with this interpretation and the  $\beta_0 \leq 1$  as a good approximation in the case of the Earth and cosmology [L11] would correspond to a boost with light velocity.

3. Before SSFR a delocalization in the moduli space  $M(P)$  of  $cd(P)$ :s takes place and generates a quantum superposition in  $M(P)$  involving different size scales of CD, different values of  $\beta_0(P)$  and possibly also different directions of the Lorentz boost.

In the SSFR a localization in the moduli space for  $cd(P)$  occurs: in particular, the size of the  $cd(P)$  and the value  $\beta_0(P)$  are fixed. The size of the  $cd$  is bound to increase in a statistical sense and this corresponds to the increase of the geometric identifiable as the temporal distance between the tips of  $cd$ .

The new value of  $\beta_0(P)$  serves as a moduli parameter for  $cd$ .  $cd(Sun)$  and  $cd(P)$  (or rather their active boundaries) are related by Lorentz boost but it is not clear whether one can say that they move relative to each other. This analog for relative motion of CDs would occur with a maximal velocity  $\beta_0 = \beta_0(Sun)$  in which case  $\beta_0(P) = 0$  would be true.

4. The analog of cosmic redshift would take place. The observed frequencies of all periodic processes for  $P$  are reshifted by  $\beta_0 \leq \beta_0(Sun) \simeq 2^{-11}$ . The Allais effect could be seen as evidence for the prediction that at the fundamental level the space-time is not connected but consists of separate space-times sheets within CDs forming a scale hierarchy.

It seems that although this view has some truth in it, it is not realistic as such.

## **3.2 About the interpretation of the parameter $\beta_0$ and the reduction of the oscillator frequency in Allais effect**

The problems related to the physical interpretation of the parameter  $\beta_0$  led to a rather detailed understanding of the frequency reduction occurring in the Allais effect.

### **3.2.1 Problems related to the interpretation of the velocity parameter $\beta_0$**

There are several longstanding questions related to the parameter  $\beta_0$  appearing in the formula  $\hbar_{gr} = GMm/\beta_0$  introduced originally by Nottale [E3].

1. Is the interpretation of  $\beta_0$  as a velocity parameter necessary? The gravitational Compton length  $\Lambda_{gr} = r_s/2\beta_0$  has no dependence on the small mass  $m$ , which conforms with the Equivalence Principle. Also the cyclotron frequencies at the monopole flux tubes of the gravitational field body are independent of  $m$ .
2. There are two preferred values for  $\beta_0$ :  $\beta_0 \simeq 1$  assigned with the Earth's gravitational field body and  $\beta_0 \simeq 2^{-11}$  assigned with the field body of the Sun.
3. The velocity of the solar system with respect to the galaxy is of the same magnitude as  $\beta_0 \simeq 2^{-11}$  assigned with the inner planets, which supports the interpretation as velocity. The interpretation of  $\beta_0 = v_0/c \simeq 1$  assigned with the Earth as a velocity of a massive object does not however look sensible. The realization that  $M^8 - H$  duality implies Hubble's law lead to the conclusion that the Hubble tension finds a solution if one has two slightly different values of  $\beta_0$  near unity applying in short and long scales.

There might be a very simple solution to these interpretational problems, which I have failed to notice.

1. In the standard quantum theory two quantum lengths characterize a massive particle. The Compton length  $\lambda_c = h/m$  and the de-Broglie wavelength  $\lambda_{de-B} = h/m\beta_0$ , where  $\beta_0 = v_0/c$  is the velocity of particle using light velocity as a unit.

2. Could the gravitational Planck constant  $\hbar_{gr}(S)$  assigned to Sun and also planets in the Bohr model for planetary orbits corresponds to de-Broglie wave length and could  $\beta_0$  correspond to a velocity 220 – 230 km/s giving  $\beta \in [(.73, .77) \times 10^{-3}]$  of the solar system with respect to galactic center. The error is about 20 per cent. If the gravitational Planck constant assigned with the Earth would correspond to the gravitational Compton length  $\Lambda_{gr}$ , the problem with  $\beta_0 = 1$  would disappear.

There are however objections against this proposal.

1. The problem is that the Bohr orbit quantization of the planetary system [K3] does not make sense for this interpretation. The quantum input in the quantization is the quantization of angular momentum and it would say that  $L_z/m$  equals to a multiple of the gravitational de-Broglie wavelength. This does not make sense in the framework of standard QM. This suggests that  $\beta_0$  cannot have an interpretation as physical velocity of a massive object. Could it correspond to an analog of light velocity? Neither can the value  $\beta_0(E) \simeq 1$  for the Earth for cosmological scales be identified as a velocity for a massive object.
2.  $M^8 - H$  duality for the gravitational Planck constant leads to a fractal generalization of Hubble's law suggesting that Hubble tension might relate to two slightly different values of  $\beta_0 \simeq 1$  in short and long length scales differing by 5-6 percent [L11]. This interpretation is not consistent with the interpretation of  $\Lambda_{gr}$  for  $\beta_0 = 1$  as gravitational Compton length.

The problem disappears if one can interpret  $v_0 \leq c$  as light velocity with  $c_{\#} = \sqrt{g_{tt}}c \leq c$  along the space-time surface in the formula for the gravitational Compton length.

3. This interpretation would have non-trivial consequences. In the case of the Sun, the disappearance of the  $1/\beta_0(S) \simeq 2^{11}$  from the formula  $\hbar_{gr}$  reduces the gravitational Compton length and gives  $\Lambda_{gr}(S) = 3 \times 10^5 \Lambda_{gr}(E)$  rather than  $\Lambda_{gr}(S) \simeq 2^{11} \times 3 \times 10^5 \times \Lambda_{gr}(E)$ . The energy  $E = \hbar_{gr}(S)f$  for a given frequency would be also reduced by  $\beta_0(S) \simeq 2^{-11}$ . And as noticed, the Bohr quantization of the planetary system would not make sense anymore.
4. It seems that the only solution to the problem is that  $\beta_0$  is quite generally identifiable as reduced light velocity  $c_{\#}$ . The reduction of  $c_{\#} = \sqrt{g_{tt}}$  to say  $c_{\#} \simeq 2^{-11}$  would however require huge gravitational fields: this does not make sense in general relativistic framework.

### 3.2.2 Warping of the space-time surfaces as a solution of the problems

A possible solution of the problem comes from a basic distinction between TGD and General Relativity noticed already during the first year of TGD.

1. TGD allows solutions of field equations, which are gravitational vacua in the sense of GRT and also gauge theory vacua for induced gauge fields. The solutions however allow warping possible only for surfaces. A thin metal plate or a sheet of paper are good examples of a system unstable against warping and therefore critical systems.
2. TGD indeed allows minimal surface solutions with a 1-D  $CP_2$  projection belonging to geodesic circle  $S^1 \subset CP_2$  for which  $M^4$  time coordinate in the rest system of the causal diamond CD is of form  $m^0 = t - \Phi/\omega$ . The induced metric of  $X^4$  given by  $ds^2 = (1 - R^2\omega^2) - dz^2 - d\omega d\bar{\omega}$  is flat and has a deformation of the Poinca group as isometries. The interpretation  $c_{\#} = \sqrt{1 - R^2\omega^2}$  as a reduced light velocity is natural: the path around a warped space-time surface is longer than along a non-warped one. There would be no gravitational force but the vacuum would be warped. This warping makes sense also for monopole flux tubes obtained as deformations of the Cartesian product  $M^2 \subset Y^2 \subset M^4 \times CP_2$ .  $M^2$  would be completely analogous to a metal plate and could be warped.
3. The warping can occur also at the level of the embedding space  $H = M^4 \times CP_2$  for the Hamilton-Jacobi structure [L2]. Now  $M^2 \subset M^2$  and  $CP_2$  degrees would mix. An analogy is provided by a cylinder surface for which the coordinates  $(z, \Phi)$  are replaced with coordinates  $z - k\phi, z + k\phi$  for which coordinate lines are dual helices.

The hypercomplex coordinates  $(u, v) \rightarrow (t - z, t + z)$  would be replaced with  $(u = T - z, v = T + z)$  where  $T$  is defined as  $T = t - \phi/\omega$ . The canonical embedding of  $M^2 \subset M^4$  with constant  $CP_2$  coordinates would be tilted towards the direction of  $S^1 \subset CP_2$ .  $CP_2$  complex coordinates would suffer a time dependent  $U(1)$  rotation  $\Phi \rightarrow \Phi - \omega t$ , which is holomorphic transformation and gives rise to a twisted Hamilton-Jacobi structure.

4. Even more general twisted Hamilton-Jacobi structures can be imagined [L2]. The TGD based model for the honeybee dance [K2] led to the proposal that there are preferred extremals as sphere bundles, which assign to a given point of the space-time surface a geodesic sphere, whose position in  $CP_2$  depends on 2  $M^4$  coordinates so that one speak of local  $SU(3)$  rotation of the geodesic sphere depending on two  $M^4$  coordinates. Could also these kinds of twistings define exotic Hamilton-Jacobi structures? Could also twistings depending on time coordinate and complex coordinate  $w$  define exotic exotic Hamilton-Jacobi structures?
5. The twisted Hamilton-Jacobi structures could be associated with monopole flux tubes serving as body parts of field bodies. This would give connection with  $\hbar_{gr}$ . Also space-time surfaces representable as graphs  $M^4 \times CP_2$  could have a twisted Hamilton-Jacobi structure and the Hubble tension [L11] could be understood if the Hamilton structures differ by a small twist in long and short cosmological scales. The volume action is for warped extremals proportional to  $c_{\#}$  and the 14 percent difference of two measured values of Hubble constant.

In the planetary system there are two options for the Bohr quantization.  $\beta_0 \simeq 2^{-11}$  would be true for the inner planets. For outer planets there are two options. Either  $\beta_0 \simeq 2^{-11}$  is true but the principal quantum number  $n$  comes as multiples of 5 or  $\beta_0 = 2^{-11}/5$  is true and Earth corresponds to the principal quantum number  $n = 1$  for outer planets or  $n = 5$  for the inner planets. For the second option  $c_{\#} = \beta_0$  would be different at the gravitational monopole flux tubes.

The value of  $c_{\#}$  can apply to gravitational flux tubes. The killer prediction is that signals about various dynamical phenomena in the Sun should appear as doubled. The first signal as ordinary radiation would arrive after 8 min 20 sec and the second copy as dark gravitational radiation after 11 days 20 hours 19 minutes.

### 3.2.3 Could warping or dark graviton pressure explain the variation of Newton's constant?

Esa Ruoho has been studying the Allais effect and has sent excellent and very inspiring questions related to the Allais effect. His questions have led to a rather detailed and highly predictive TGD based model for the Allais effect based on the notion of warping distinguishing between GRT and TGD.

One of the latest questions is whether the predicted large reduction of the light velocity, which is due to warping made possible only for space-times identified as 4-surfaces, could reflect itself in the value of the gravitational constant  $G$ .

Indeed, in 2015 a team of researchers led by J. D. Anderson published a study in Europhysics Letters [E4] reporting that measurements of Newton's gravitational constant ( $G$ ) over several decades appear to oscillate with a period of  $5.899 \pm 0.062$  years. The periodicity in  $G$  measurements matches the approximately 5.9-year oscillation found in Length of Day (LOD) variations, which are fluctuations in Earth's rotation rate. This phenomenon would be analogous to the variation of the pendulum period in the Allais effect.

Could warping, which predicts that the speed of light can have values  $c_{\#} \leq c = 1$  (here the units with  $c = 1$  are used), related to the far too large variation associated with  $G$  measurements? There are two options. Either the classical gravitational force is affected or the dark graviton beam from the Sun affects the force by creating the analog of radiation pressure.

1. Warping does not affect the gradient of the gravitational potential  $\Phi_{gr}$  appearing in  $g_{tt} = 1 - 2\Phi_{gr}$  of the gravitational potential to which the gravitational force is proportional. Indeed, a detailed calculation shows that there is no classical effect.
2. In the case of Schwarzschild metric, the radial gravitational acceleration  $dr^2/ds^2$  as predicted by GRT is given by

$$\frac{d^2r}{dt^2} = -\frac{g^{rr}}{2}\partial_r g_{\mu\nu} \frac{dx^\mu}{ds} \frac{dx^\nu}{ds} . \quad (3.1)$$

$\partial_r g_{\mu\nu}$  is non-vanishing only for

$$g_{tt} = 1 - 2\frac{r_s}{r} , \quad g_{rr} = -\frac{1}{g_{tt}} , \quad g_{\theta\theta} = -r^2 , \quad g_{\phi\phi} = -r^2 \sin^2(\theta) . \quad (3.2)$$

3. The radial equation for the geodesic motion for the motion (which is planar) reads as

$$\frac{d^2r}{dt^2} = [-(1 - 2\frac{r_s}{r}) \times [\frac{r_s}{r^2}(1 - (\frac{dr}{dt})^2) + r(\frac{d\phi}{dt})^2]] . \quad (3.3)$$

In GRT,  $c_{\#} = \sqrt{g_{tt}}$  extremely close to the value  $c_{\#} = 1$  for the solar system.

4. In TGD, the prediction of GRT for the value of  $g_{tt} = c_{\#}^2 \leq 1$  is affected by the warping. In a good approximation one has

$$g_{tt} = c_{\#}^2 \rightarrow c_{\#}^2 - R^2 \times \omega^2 . \quad (3.4)$$

5. This replacement does not affect the radial acceleration determined by  $\partial_r g_{tt}$ . Hence the effective value of  $G$  associated with the classical gravitational force is not affected so that the intuitive expectation is correct.

Could the radiation pressure of the graviton flux coming from the Sun or from the Earth itself affect the effective value of  $G$ ? This pressure decreases like  $1/r^2$  just as the gravitational force does. For the Sun graviton flux would concentrate to the wavelength  $\lambda = \Lambda_{gr} = 3000$  km and the energies of gravitons would vary in the range  $1 - 10^5$  eV. For the Earth the wavelength would be  $\lambda = \Lambda_{gr} = 5$  mm.

1. If the gravitons with a shared gravitational Compton length  $\lambda = \Lambda_{gr} \sim R_E/2$  from the Sun induce a transversal gravitational force, the variation of  $G_{eff}$  could be basically due to the emission of dark gravitons from the Sun. The intensity of the emission of gravitational waves should have  $T = 5.9$  years as a period. Sunspot cycle has a period  $T_S = 11$  years (varying in wide limits) and is part of a 22 year cycle.  $T \sim T_S/2$  suggests a chaotic period doubling dynamics.
2. In TGD, sunspots relate very closely to the magnetic monopole flux tubes. The monopole flux loops emitted by reconnection mechanism from the Sun carry solar wind, radiation and also gravitationally dark gravitons with  $\lambda = \Lambda_{gr} \simeq R_E/2$  so that frequency-/wavelength resonance amplifies the effect of gravitons. Therefore variation of  $G_{eff}$  would reflect the dynamics of the monopole flux tubes.

The receipt of dark gravitons induces transversal gravitational force and therefore has an effect on the rotation period of the Earth and could explain the correlation with the variation of LOD.

### 3.2.4 Warping of the space-time surfaces and dielectric constant

The flat warped space-time surfaces are characterized by the reduced light-velocity  $\beta_0 = c_{\#}/c \leq 1$ . There is a criticality with respect to the variations of  $c_{\#}$  (instability of metal plates illustrates this). Also the twisted Hamilton-Jacobi structures would be characterized by  $c_{\#}$ .

The criticality of the warping could induce or accompany various kinds of quantum criticalities. In the case of the Allais effect, this kind of quantum criticality would explain the variation of the pendulum frequency cannot be explained in terms of gravitation.

Quite generally, one can write  $f_{\#} = c_{\#}/\lambda = f/n$ , where  $n = c/c_{\#}$  is analogous to the refractive index appearing in electrodynamics in presence of matter. In Maxwellian electrodynamics, refractive index relates to the relative dielectric constant  $\epsilon_r$  via the formula  $n = c/c_{\#} = \sqrt{\epsilon_r}$ . Could reflective index and dielectric properties have a geometric description in terms of the warping of the space-time surface? If so, the warping of the space-time surface could be seen directly via the reflection of light!

Refractive index depends on frequency. This can be understood in terms of quantum criticality implying the value of  $c_{\#}$  associated with the massless extremal assignable to the photons depends on frequency. At resonance, at which  $\epsilon_r$  diverges, the value  $c_{\#}$  would in the ideal case vanish: there would be no propagation of signals. The standard interpretation would be in terms of absorption of the signal by atoms, which contribute to the resonance frequencies.

How the criticality of warping could manifest itself in critical systems?

1. For a harmonic oscillator, the frequency is given in terms of force constant and mass as  $\omega = \sqrt{k/m}$ . A reasonable dimensional guess is that the force constant  $k$  characterizing the electromagnetic force is proportional to  $(c_{\#}/c)^2$ . For instance, cyclotron frequency would be proportional to  $c_{\#}$ . More generally, the Coulomb force in a dielectric is scaled from its vacuum value by  $1/\epsilon_r = (c_{\#}/c)^2$ . Also capacitance of a capacitor would be proportional to  $(c_{\#}/c)^2$ . The variation of  $c_{\#}$  at quantum criticality would make it possible to change the contribution of the electromagnetic force.
2. Gravitational masses have always the same sign so that the notion of dielectret does not make sense and  $c_{\#}$  is not expected to play any role: this conforms with the character of warping. For instance, the gravitational force created by a constant mass density  $\rho$  corresponds to potential energy proportional to  $Gm\rho r^2$ , which is harmonic oscillator potential energy. The force constant  $k \propto Gm\rho$  does not depend on  $c_{\#}$ .
3. If the system is in an equilibrium involving electromagnetic and gravitational forces, the variation of  $c_{\#}$  appearing in the electromagnetic component of force could make possible the loss of equilibrium. The tuning of  $c_{\#}$  could allow the field body to change the equilibrium point of a physical system and even destroy or create the equilibrium. In biology the generation of nerve pulse, the splitting of DNA double strand preceding transcription and replication could serve as examples of this.

There might also be a connection with the quantum criticality associated with the mild classical non-determinism assignable to the 3-D singularities of space-time surfaces. These singularities can be regarded as edges of the space-time surface and that the time evolution of 3-surface is analogous Brownian motion. What comes to mind is that the singular 3-surfaces could define interfaces of regions with different values of  $c_{\#}$  as loci of quantum criticality. Could the gravitons propagating along monopole flux tubes experience refraction during the solar eclipse.

Besides dielectric constant, electrodynamics is characterized by conductivity. Could the analog of Brownian motion provide a classical space-time correlate for the finite conductivity?

### 3.2.5 A connection with the frequency reduction in Allais effect

There would be a connection with the model explaining the Allais effect [L10].

1. There is a surprisingly large reduction of the value of the oscillation frequency having upper bound  $\Delta f/f \leq 2^{-11}$ . This brings in mind  $\beta_0(S)$  and the proposal was that the quantum critical transitions involve fluctuations reducing the oscillator frequency satisfying the formula  $E = h_{gr}(E)f$ : now the mass of the pendulum would be in the role of the small mass. The modification  $\Delta c_{\#}/c_{\#} \simeq 2^{-11}$  would be needed. The gravitational fluctuations  $\Delta c_{\#}/c_{\#}$  required to produce the effect would be quite too large as compared to the reduction of the value of  $c$  from its maximal value by  $GM_S/AU = r_s(S)/2AU \sim 10^{-9}$  and  $GM_E/R_E = r_s(E)/2R_E \sim 10^{-9}$ .
2. The modification of the inherently quantum critical Hamilton-Jacobi structure makes a large change  $\Delta c_{\#}/c_{\#} \simeq 2^{-11}$  possible. It could occur at the level of the ordinary space-time surface or at the level of the field body. In the case of a gravitational pendulum, the reduction of

oscillation frequency  $\omega_1 \propto \sqrt{g/l} = \sqrt{GM/lR^2} = c_{\#,1}r_s/2R^2$  to  $\omega_2 = c_{\#,2}r_s/R^2$  would be needed. That the velocity of the solar system with respect to the galactic center is near to  $\beta_0 = c_{\#} \simeq 2^{-11}$  could follow from the warping in this framework. One could say that the solar system moves with a reduced light-velocity! One can wonder how general this phenomenon is.

The physical mechanism causing this modification should be identified and explain the large value of  $\Delta c_{\#}/c_{\#}$ .

1. Warping is a critical phenomenon. Space-time warping as a fundamental quantum critical phenomenon could accompany and even induce many kinds of quantum critical phenomena, in particular Allais effect.
2. The model for the Allais effect proposes that diffraction-like effect for the gravitational flux tubes meaning a deviation of the monopole flux tubes, analogous to the deviation of flow lines of a hydrodynamic flow past solid object, could produce reduction of the effective gravitational flux. This would reduce the effective gravitational mass  $M_S$  experienced by the pendulum but the reduction is expected to be extremely small.
3. Could gravitational Planck constant and  $c_{\#}$  of the gravitational field body change?  $\Delta f/f \leq 2^{-11}$  is not far from the electron-proton mass ratio  $m_e/m_p \simeq 1/1880$ : the deviation is 9 per cent. If the field body contains hydrogen atoms, their ionization to protons and electrons transforming to ordinary electrons would reduce  $h_{gr}$  by the required amount.

The hydrogen atoms should be Rydberg atoms with a very small binding energy and therefore with very large size: this is indeed possible at the field body. The dropped electrons should have smaller energy compensating for the energy needed for the energy needed for ionization. The transition could take place by tunnelling and therefore involve a pair of "big" state function reductions (BSFRs).

This kind of phase transition should occur at quantum criticality assigned with the beginning of the solar eclipse? Why the turning of the monopole flux tubes meeting the Moon should induce a phase transition leading to the transformation of dark electrons to ordinary electrons? Are the electrons so near to ionization state the turning ionizes them?

### 3.2.6 How to test the proposal?

How could the proposal  $h_{gr} = GMm/c_{\#}$  implying the formulas for the gravitational Compton length be tested?

1. For the dark cyclotron the transitions at the magnetic body, the dependence of cyclotron energy on  $m$  disappears. For other frequencies this is not the case and one would have  $E = h_{gr}f = (GMm/2\pi c_{\#}) \times f$ . A possible test is to look whether the energies for slightly different masses  $m$  differ. The second possibility is that  $c_{\#}$  varies for critical phenomena.
2. Examples would be proton and hydrogen atom with a relative mass difference of order  $2^{-11}$  and proton and neutron with mass difference of .14 per cent. One can imagine an entire spectroscopy allowing to test the notion of gravitational Planck constant by using the effects caused by the transformation of gravitationally dark photons to ordinary ones. Biophotons could emerge as an outcome of this transformation [K1].

### 3.3 The simplest model of Allais effect found hitherto

The proposed ideas allow us to imagine many concrete models. The following proposal is perhaps the simplest model that I have been able to imagine hitherto.

1. The criticality of the warped  $M^4$  defining a twisted Hamilton-Jacobi structure [L2, L11] could accompany the quantum criticality during the beginning and end of the eclipse. Suppose that the criticality sets on during the transition period. The value of  $c_{\#}$  fluctuates at criticality and can have large values.

2. Suppose that the time component  $g_{tt} = 1 - 2\Phi_{gr}$  of the induced metric ( $\Phi_{gr}$  is gravitational potential) is reduced during the eclipse in the shadow of the Moon which is therefore analogous to a dielectric. For large values of  $c_{\#}$ , the gravitational contribution to  $g_{tt}$  is negligible and  $c_{\#}$  makes itself physically visible. If the contributions of warping and gravitation of the Sun and Moon are additive, the gravitational force as a gradient of the gravitational potential is not affected. This would partially explain the absence of longitudinal effects.
3. The fluctuations of  $c_{\#}$  would explain the fluctuations of the pendulum frequency proportional to  $\sqrt{c_{\#}}$ . The mere change  $c \rightarrow c_{\#}$  in the transition zone would not be enough. The fluctuation must occur at least in the transition zone.

How to explain the transversality of the Allais effect? The following picture is the simplest one found hitherto.

1. Longitudinal effects are absent since the classical gravitational force is not affected. Gravitational waves are transversal. Could they explain the transversal effects, which are much larger than those caused by the ordinary gravitational torque? Could the large value of gravitational Planck constant  $\hbar_{gr}$ , implying quantum criticality, make the gravitational pendulum an extremely sensitive detector of gravitational waves?
2. Assume that the value of  $c_{\#}$  is changed inside the shadow cone of the Moon.  $c_{\#}$  could be constant inside the shadow cone but fluctuations only in the transition regions would occur. Snell's law implies that the reflection and refraction angles are largest during the transition phases. At the center point of the shadow cone the reflection occurs backwards and refraction forwards. Therefore  $c_{\#}$  could fluctuate also inside the transition region but would have a smaller transversal effect, which would vanish at the middle point of the Moon's shadow. The situation at the middle point would be dominated by the ordinary gravitational force apart from a vertical momentum transfer from gravitons, which could affect the vertical gravitational force.
3. Due to the large value of  $\hbar_{gr}$  and  $c_{\#}$ , reflection and refraction of the gravitational waves from the pendulum could become large effects during the transition. Dark gravitons with large  $\hbar_{gr}$  have large energy  $E = \hbar_{gr}f$  and momentum  $p = E/c_{\#}$ . During the transition periods large reflection angles become possible by Snell's law and this causes large transfer of transversal momentum. This could explain the large change of the oscillation plane.

This model differs from the model based on the diffraction of the monopole flux tubes assumed to define analog of hydrodynamical flow since in this case the classical gravitational flux would be deflected and induce effective screening. This could occur in rather long length scales and there is evidence for a characteristic scale of 44 m.

## 4 A model for the variation of Newton's constant based on dark gravitation radiation pressure

The proposal [L10] is that the radiation pressure of the dark gravitational radiation from the Sun and perhaps also from the Earth can produce effects comparable to the gravitational force of the Sun. This radiation is extremely weak. Could quantum coherence in the length scale defined by gravitational-Compton wavelength enhance the intensity of the gravitational radiation?

### 4.1 General description of the model

The first guess was that the gravitational radiation at energy range  $1 - 10^5$  eV assumed to be produced by Sun could somehow transform to dark gravitons with Compton length equal to gravitational wavelength  $\lambda = \Lambda_{gr} = r_s(Sun)/2\beta_0(Sun \sim 3000)$  km  $\sim R_E/2$ , which does not depend at all on the energy of the graviton. This would guarantee the quantum coherence in the Earth scale making possible large effects. In microscopic scales the gravitational radiation is generated by thermal collisions in solar plasma and in macroscopic scales by hydrodynamic fluctuations.

The macroscopic mechanism is more plausible as a candidate for producing the gravitational dark gravitation.

The generation of quantum coherence as transformation of ordinary gravitons to dark gravitons is however difficult to understand. One can also consider a purely TGD based mechanism in which dark gravitons are generated at the gravitational magnetic body of the Sun, i.e. monopole flux tube loops associated with the Sun and mediating the gravitational interaction. The scale of Sunspots is indeed given by  $\Lambda_{gr}$  [L4]. The gravitational radiation would be generated by the acceleration of charged particles in the magnetic field of the gravitational flux tubes.

The observed relative variation of Newton's constant is between .01-.1 percent. The value of  $c_{\#}/c = 2^{-11} = .5 \times 10^{-3}$  is one 1/2 of the lower bound. This observation might help in the attempts to understand about what is involved.

It is good to start with the possible gravitonic pressure caused by the Sun. The gravitational force of the Sun on the Earth must be compared to the total momentum flux produced by dark gravitons directed at the Earth to see whether the hypothesis can make sense. One must also test the corresponding hypothesis for other planets also in the case of the Earth's gravitational field.

1. The Sun is estimated to produce energy with a power of  $P = 1.3 \times 10^8$  W through graviton radiation by thermal collisions and hydrodynamic fluctuations. The energy of the gravitons would in the range  $1eV - 10^5$  eV. Thermal collisions, hydrodynamic fluctuations, and photoproduction by the decay of photons to gravitons.

The generated total power is estimated to be  $P = 1.3 \times 10^8$  W and correspond to a single nuclear power plant. It would give to give rise to a total momentum flux of  $F = P/c = 1.3/N$  N which is extremely small and only a fraction of the flux corresponding to the area of the Sun equal to the projection of the Earth to the Sun, area of a typical Sunspot, arriving from the surface of the Sun contributes to the gravitational radiation pressure on the Earth. The intensity of the radiation flux decreases like inverse distance squared, just like the ordinary gravitational force. Monopole flux tubes would however make possible targeted emissions and 1/distance squared behavior is true only in statistical sense.

2. In absence of quantum coherence, the radiated power is proportional to the number  $N$  of emitters. Quantum coherence should effectively replace  $N$  with  $N^2$ . At least for the thermal radiation with high energies, it is difficult to see how this could amplify the momentum flux so that it would be comparable to the gravitational force between the Earth and the Sun. It seems more likely that the mechanism is related to the acceleration of gravitationally dark charged particles in the magnetic field of dark gravitational flux tubes characterized by  $\hbar_{gr}$ .

$\Lambda_{gr}$  is the same regardless of the energy of the graviton  $E$ . The origin of quantum coherence and large effect would be here.  $\Lambda_{gr} = 3000$  km that would be a wavelength and about half the radius of the Earth and could lead to effect in the scale of the entire Earth. Also the emission rate of the radiation in constant magnetic field of the Sunspot is proportional to  $Gm^2 f_c^2$ ,  $f_c = eB/m$  and is independent of the mass of the  $m$  charged particle so that the radiation power is proportional to the total number of charged particles.

3. The gravitational force of the Sun on the Earth is given by

$$F_{gr} = \frac{GM_S M_E}{R^2} = (1/2)(r_S/m) \times c^2 \times (M_E/kg)/(R(Sun)/m)^2$$

The mass of the Earth is  $M_E/kg = 6 \times 10^{24}$  and  $R/m = 1.5 \times 10^{11}$ , Schwarzschild radius  $r_s = GM/c^2$  of the Sun is  $r_S/m = 3 \times 10^3$ . The distance  $R(Sun)/m = AU/m = 1.5 \times 10^{11}$  m. This gives

$$F_{gr} \simeq 1.5 \times 3.54 \times 10^{22} \text{ N} .$$

The order of magnitude difference between  $F_{gr}$  and the force caused by the ordinary gravitational radiation pressure is enormous.

## 4.2 A model for the emission of dark gravitons

Consider now a model for the emission mechanism of gravitationally dark gravitons from the monopole flux tubes mediating the gravitational interaction.

1. Dark charges at the gravitational flux tubes of radius  $\Lambda_{gr}$  and extending to the Earth would produce the force as radiation pressure  $F = P/c$ , where  $P$  is the emitted power.
2. For dark gravitons, quantum coherence is assumed to produce a momentum proportional to the square  $N^2$  of the number of emitters in the emitting region rather than to  $N$  as in absence of coherence.
3. Emission power  $P$  and corresponding momentum transfer rate  $F = P/c$  due to the radiation pressure for gravitational waves in a magnetic field  $B$ . The force produced by radiation pressure should be about  $10^{-2} - 10^{-3}$  times smaller than the gravitational force. The lower bound is one 1/2 of  $\beta_0 \simeq 2^{-11}$ .

### 4.2.1 Parameters of the model

Consider first the parameters of the model.

1. The flux tubes should extend to the Earth and therefore have the length  $L = 1 \text{ AU} = 1.5 \times 10^{11} \text{ m}$ . Their thickness is  $\Lambda_{gr} = r_S(\text{Sun})/2\beta_0(\text{Sun}) \simeq 3 \times 10^6 \text{ m} \sim R_E/2$  for  $\beta_0(\text{Sun}) = c_{\#}/c = 2^{-11}$ . The volume of the flux tube is given by

$$V = L\Lambda_{gr}^2 = \frac{\pi}{2} \times \frac{\text{AU}}{\Lambda_{gr}} \Lambda_{gr}^3 \simeq 5 \times 10^4 \Lambda_{gr}^3 .$$

2. A geometrically natural simplifying assumption is that there is about 1 unit charge per volume determined by the magnetic length  $L_B$  giving rise to a number density  $dn/dV = 1/L_B^3$ ,  $L_B = \sqrt{\hbar/eB}$ . A convenient numerical formula for the magnetic length is  $L_B = r \times 10^2/\sqrt{B/T}$ ,  $r \simeq .26$  (*Angstrom* =  $10^{-10} \text{ m}$ ).
3. The charge density would be given by

$$\frac{dn}{dV} = \frac{1}{L_B^3} = r^{-3} \times y^{3/2} \times 10^{-6} \times \frac{1}{a_0^3} .$$

The total number  $N$  of unit charges at the flux tube would be

$$N = \frac{dn}{dV} \times V = \frac{1}{L_B^3} \times \frac{\pi}{2} \text{AU} \times \Lambda_{gr}^2 = r^{-3} \frac{y^{3/2}}{\times} \frac{\pi}{2} \times 5 \times 10^{-2} \times \left(\frac{\Lambda_{gr}}{a_0}\right)^3 .$$

Note that one has  $\Lambda_{gr}/a_0 = 2 \times 10^{16}$ .

### 4.2.2 Radiation power and force generated by a single elementary charge

There exists a formula for the power of the gravitational radiation in a constant magnetic field  $B$  prevailing inside the monopole flux tube. Since cyclotron frequency  $f_c$  is inversely proportional to the mass of the particle, the power does not depend on the mass  $m$  of the charge.

1. The power of the gravitational radiation emitted by the unit charge  $e$  in a constant magnetic field is given by

$$P = \frac{4}{3} \frac{Ge^2}{c^3} \beta^2 \gamma^4 \times y^2 \text{ J/s} .$$

Here one has  $y = r \times B/T$ ,  $r = .2566 \simeq .26$ .

2. The corresponding force as a transfer of dark gravitational momentum is

$$F = \frac{P}{c} = \frac{4}{3} \frac{Ge^2}{c^3} \beta^2 \gamma^4 y^2 N .$$

The numerical estimate is obtained by using the values  $G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$  and  $e = 1.6 \times 10^{-19} \text{ C}$ .

3. Could the cyclotron frequency of a proton in the magnetic field of the solar magnetic flux tube define a preferred frequency scale for dark gravitons. The huge value of the solar gravitational Planck constant  $(r_s(\text{Sun})/L_p)2\pi$  for a proton implies that the dark energy of proton, which does not depend on the mass of the charged particle, is about  $290(f_c/Hz)m_e$ . This conforms with the idea that charged particles at the monopole flux tubes are relativistic.

### 4.2.3 Total radiation force

Assuming that quantum coherence corresponds to the replacement  $N \rightarrow N^2$  in the expression for the total power and force, one has

1. The total radiation force is

$$F_{rad} = N^2 F = b \times y^5 \beta^2 \gamma^4 \times 5 \times 10^{22} N \quad y = r(B/T) .$$

Here one has  $r \simeq .26$  and  $b = (\pi/2)^2 \times 1.24^2 \times 6.7 \times 1.6^2/2.7 = (\pi/2)^2 \times 9.7677 \times 10^{-2} \simeq .24$ . One has  $5b = 1$ .

2. The condition

$$F_{rad} \leq 10^{-2} F_{gr} \quad , \quad F_{gr} = 3.54 \times 10^{22} N .$$

gives a constraint on the parameter  $y$

$$y \leq r^{1/5} \left( \frac{r}{\gamma^4 \beta^2} \right)^{1/5} \simeq .51 \times \left( \frac{(1-x)^2}{x} \right)^{1/5} \leq 1 \quad , \quad x = \beta^2 \quad , \quad r = 3.54 \times 10^{-2} .$$

For  $x \rightarrow 1$  the upper bound for  $y$  approaches 0.

3. The condition  $y \leq 1$  is natural and gives a condition for  $x = \beta^2$ . Using  $\gamma^4 = 1/(1-x^2)^2$ , one obtains

$$\frac{x}{(1-x)^2} \geq r .$$

$y = 1$  corresponds to the root for  $x = r(1-x^2)$ , given by  $x = \frac{1}{2}(2-1/r) \pm \sqrt{-2/r+1/r^2}$ .  $x$  is real for  $r \leq 1/4$ , satisfied for  $r = 3.54 \times 10^{-2}$ .  $y = 1$  ( $B = .26 \text{ T}$ ) corresponds to  $x = \sqrt{2}-1$  and  $\beta = \sqrt{\sqrt{2}-1} \simeq .64$ . Relativistic velocities would be required for weak magnetic fields and this suggests stringent bounds of the strength of  $B$ .

4. Could the charged particles at flux tubes somehow get their relativistic energies? TGD predicts an entire hierarchy of hadron physics labelled by Mersenne primes. There already exist indications for  $M_{89}$  hadron physics with a mass scale 512 times that for ordinary hadrons [L4, L9, L8]. The TGD based view about the mechanism producing solar energy and solar wind is based on the decay of  $M_{89}$  hadrons, in particular  $M_{89}$  nucleons to ordinary hadrons, at the surface layer of the Sun. This would produce highly relativistic charged particles.

### 4.3 What about the other planets and the gravitational radiation pressure generated by the Earth?

One can consider the condition also for other planets besides Earth with distance  $R_P$  from the Sun. The number  $N$  of unit charges would be scaled as  $N(E) \rightarrow (R_P/AU)N$  and  $F_{rad}$  is scaled by  $F_{rad}(E) \rightarrow F_{rad}(E)(R_P/AU)^2$ .  $F_{gr}$  would be scaled by  $F_{gr}(E) \rightarrow (AU/R_P)^2(M_P/M_E)F_{gr}(E)$ .

For outer planets  $F_{gr}$  would be reduced and  $F_{rad}$  would increase if the value of  $B$  is taken to be the same. Without additional conditions on the strength of the magnetic field guaranteeing that  $F_{rad}/F_{gr}$  is constant, the ratio would depend on the planet. The condition would read as

$$\frac{B(P)}{B(E)} = \left(\frac{AU}{R(P)}\right)^2 \left(\frac{M_P}{M_E}\right)^{1/2} .$$

The strength of  $B(P)$  would depend on distance roughly like  $1/R(P)^2$ , just as in the case of gravitational force or the magnetic field of a monopole.

One can also ask whether  $F_{rad}$  due to the Earth could be important. In this case  $F_{gr}$  for a mass of 1 kg is scaled down to about 10 N and  $\Lambda_{gr}$  is scaled down to 5 mm. For a density of  $10^3$  kg/m<sup>3</sup>, the volume  $\Lambda_{gr}^3$  corresponds to mass of  $1.25 \times 10^{-4}$  kg so that the  $F_{gr}$  would be at the surface of the Earth about  $1.25 \times 10^{-3}$  N. For the length  $L = R_E$  of a monopole flux tube the (emanating from the interior of the Earth?) there would be a scaling down of  $F_{rad}$  by  $(R_E/AU) \times (\Lambda_{gr}(E)/\Lambda_{gr}(S))^2 \sim 10^{-5} \times 10^{-16} \simeq 10^{-21}$ .

For  $F_{rad} = 3.5 \times 10^{19}$  N corresponding to the reduction factor  $10^{-3}$ , one would have  $F_{gr} \sim 3.5 \times 10^{-2}$  N.  $F_{gr}$  would be by an order of magnitude larger than the naive estimate and corresponds to a reduction factor  $10^{-2}$  which corresponds to the upper bound for  $\Delta G/G$ . Maybe the combined effects of the Sun and Earth could explain the fluctuations of  $G$ .

### 4.4 The upper bound for the strength of the magnetic field of monopole flux tube equals to the strength of the "endogenous" magnetic field

By using scaling arguments, one can deduce an estimate for  $y_{max}$  for the Earth and therefore for the maximum value  $B_{max}$  of the Earth's magnetic field by starting from the Sun-Earth system with  $y_{max}(S, E) \simeq .25$  and from the proportionally  $y_{max} \propto (F_{gr}/L^2)^{1/5}$ , where  $L$  is the length of the monopole flux tube.

1. In the estimate the  $F_{gr}(Sun, Earth)$  is replaced with the force between Earth and a mass blob with the density of water  $\rho_w = 10^3$  kg/m<sup>3</sup> with a volume  $\Lambda_{gr}^3(E)$  and having mass  $m(\Lambda_{gr}) = \rho_w \Lambda_{gr}(E)^3$ . This gives  $m(\Lambda_{gr}) \simeq .75 \times 10^{23} m_p$ .  $F_{gr}$  is scaled down by the factor  $M_S/m(\Lambda_{gr})$ . From  $M_S/m_p = 1.189 \times 10^{57}$  one has  $M_S/m(\Lambda_{gr}) = 1.59 \times 10^{24}$ .
2. In the estimate  $F_{rad}(Sun)$  is replaced by that for the Earth. The radiation force satisfies  $F_{rad} \propto L^2$ . Assume that  $L = R_E$  holds true at the surface of the Earth. The scaling factor for  $F_{rad}$  is  $(R_E/AU)^2$ , where one has  $AU/R_E \simeq .235 \times 10^5$ .
3. The overall scaling factor in  $y_{max}(S, E) \rightarrow y_{max}(E)$  is  $(M_S/m(\Lambda_{gr}))^{-1/5} \times (AU/R_E)^{2/5}$ . The outcome is  $y_{max} = .72 \times 10^{-3}$ . This gives  $B_{max} = 1.87 \times 10^{-4}$  Tesla which corresponds to .187 Gauss. The strength for the Earth's magnetic field varies in the range .25-.65 Gauss. Amazingly, the empirical estimate for the strength of the "endogenous" magnetic field at monopole flux tubes is .2 Gauss!
4. The upper  $y_{max}(P)/y_{max}(E)$  scales like  $(R_P/R_E)^{4/5}$ , where  $R_P$  denotes the radius of the planet. There is no dependence on  $\Lambda_{gr}$ . If the density of the volume defined by  $\Lambda_{gr}$  is that of water, this predicts for Mercury  $y_{max}(P)/y_{max}(E) \simeq 2.1$  for Mercury.

Jupiter is the largest planet with equatorial radius  $R_P = 11.2R_E$ . Its surface density is  $\rho \simeq x\rho_w$ ,  $x = 2 \times 10^{-4}$ . This gives  $y_{max}(P)/y_{max}(E) \simeq (R_E/R_J)^{4/5} \times x^{1/5} \simeq .026$  for the endogenous magnetic field of Jupiter. The strength of Jupiter's total magnetic field, expected to be stronger than the endogenous magnetic field, is  $2 \times 10^4$  times that of the Earth: there is a difference of 6 orders of magnitude.

One can argue that the model involves numerical constants of order unity. Since  $y_{max}$  is expressible as a fifth root, they do not have any significance. It seems that by applying these arguments Sun-planet pairs and planets could give very powerful constraints on the endogenous magnetic field strengths involved.

## 5 Questions by Esa-Juhani Ruoho

Esa-Juhani Ruoho made some questions related to the TGD view of Allais effect, which inspired the considerations of this article as an attempt to update the earlier model by bringing in the rather dramatic developments that have occurred during last years.

### 5.1 Allais effect as interference and diffraction effect in long scales and transversality

[ER1] In your TGD model, the Allais effect is an interference effect involving gravitational Planck constant  $h_{gr}$  having a very large value. The key finding from the analysis of Duif (2004) [E2] and Goodey et al. (2022) [E8]) is that the anomaly is primarily horizontal - instruments sensitive to horizontal forces detect signals  $10^3$ – $10^5$  times larger than vertical gravimeters. Allais's own anisotropy coefficient is  $\sim 10^{-6}$ , while classical tidal prediction gives  $\sim 10^{-13}$ . Does TGD predict this horizontal dominance, or is the amplification at large  $h_{gr}$  isotropic?

[MP1] I have considered a TGD based explanation as interference of classical dark gravitons/gravitational waves arriving from the Sun and Moon [K4]. In the recent view of TGD, I have considered classical hydrodynamic model and quantum diffraction model, which also involves interference.

1. A possible TGD based view is that the gravitational force of the Sun involves a contribution from gravitational waves. It could be modelled in terms of a gravitational flux as analogous to an incompressible hydrodynamical flow. The monopole flux tubes arriving from the Sun would be analogs of flow lines and idealizable as strings so that a connection with string model emerges.

The Moon could be modellable as an obstacle for this flow. This obstacle could be partially transparent meaning the presence of reflection and refraction of gravitational waves. In long length scales there would be diffraction. The gravitational flux would be conserved for the flux tubes.

2. Quantum version of this picture would be analogous to quantum diffraction of particles as 3-surfaces identified as monopole flux tubes connecting Sun or Earth and idealizable as strings so that a connection with string model description of gravitation emerges. Moon would define the obstacle and the scattering would involve diffraction besides reflection and refraction. The analogy with the double slit experiment is obvious. This would give a stringy variant of quantum diffraction in a reasonable approximation.
3. The gravitational Compton wavelength  $\Lambda_{gr} = r_s(\text{Sun})/2\beta_0$ ,  $\beta_0 \simeq 2^{-11}$  of the Sun is on the order of  $R_E/2$ , where  $R_E$  is the Earth's radius. Therefore interference and diffraction on these scales could occur. For the Earth  $\Lambda_{gr} = r_s(\text{Earth})/2\beta_0$  with  $\beta_0 \simeq 1$  is about .5 cm. The Moon should have the same value of  $\Lambda_{gr}$  in the solar gravitational field.
4. This would make a precise prediction for the diffraction pattern in terms of Bessel function. The large value of the gravitational Planck constant would be essential for the effect. The findings of [E12] suggest a wavelength of 44 m. To my view the quantum diffraction for the flux tubes inducing a modification of  $g$  represents a transversal effect in the scale of the Earth.
5. The Sun is known to be a weak source of gravitational waves in frequency range  $10^{14} - 10^{19}$  Hz. The wavelength range is  $1 - 10^{-5}$   $\mu\text{m}$ . This range is very far from the empirical estimate 44 m. If the wavelength is estimated from energy by using ordinary value of Planck constant, then for the gravitational Planck constant of Earth-proton system a scaling down of frequency

range by factor  $\sim 2.4 \times 10^{13}$  takes place and the wavelength range becomes  $2.4 \times 10^7$  m - 240 m. The upper bound is somewhat smaller than the solar radius and the lower bound is roughly 5 times larger than the empirical estimate 44 m.

During a couple of months after the above comment, the model of the Allais effect has developed considerably.

Already during the first year of TGD (1977) I learned that almost any variational principle allows so-called warped extremals, which are flat so that there is no gravitational force. Also gauge forces vanish so that vacuums are in question and the energy is only due to the cosmological constant as an extremely small coefficient of the volume contribution to the action.

These extremals distinguish between General Relativity and TGD. There is an analogy with a flat metal plate, which is unstable against oscillations in single transversal degrees of freedom analogous to waves. These extremals are unstable and therefore critical and are an excellent candidate for inducing quantum criticality characterizing the Allais effect.

More precisely, the standard  $M^4 \subset H = M^4 \times CP_2$  is embedded to  $H$  in such a way that the standard  $M^4$  is tilted towards  $M^4 \times S^1 \subset H$  so that warping occurs. The velocity of light for these extremals is reduced to  $c_{\#} < c$ . This would explain the large reduction of the frequency of the pendulum since force constant is from dimensional argument proportional to  $\sqrt{c_{\#}/c}$ . The reduction of light-velocity occurs also in electrodynamics of matter and the refractive index  $n$  could be identifiable as  $n = c/c_{\#}$  and in terms of the relative dielectric constant  $n = \sqrt{\epsilon_r}$ . Many-sheeted space-time would be seen by bare eyes as light reflection! Of course, also the many-sheeted structure is seen: we see surfaces everywhere.

This would suggest that the transversal effect could be due to the reflection and refraction of gravitons with large  $\hbar_{gr}$  at quantum criticality due to the fluctuations of  $c_{\#}$ . In longer scales the deflection of gravitational flux tubes analogous to diffraction would be involved.

## 5.2 Anomalies in geometric transitions

[ER2] The C1/C4 pattern — anomalies in geometric transitions (first and fourth contact), absence during totality — is the strongest observational result, confirmed for instance by Wang and Kuusela (1992) [E7, E13]. Does the TGD interference mechanism produce transient phenomena at the beginning/end of the alignment and not a continuous effect during the maximum coverage time?

[MP2] One must model the interaction of gravitational flux tubes with the conical pendulum. One can start from a harmonic oscillator model for the conical pendulum and perform a quantization using the gravitational Planck constants of the Sun or the Earth.

The huge values of gravitational Planck constant imply that small values of the harmonic oscillator quantum number are involved. The changes of this quantum number at criticality could explain the large fluctuations as quantum critical fluctuations assignable to the transition to the eclipse. The effect would not be gravitational but quantum mechanical and due to the large value of  $\hbar_{gr}$  predicted by TGD based quantum ontology.

The picture discussed in the section "The simplest model of Allais effect found hitherto" would look like follows.

1. Suppose that the time component  $g_{tt} = 1 - 2\Phi_{gr}$  of the induced metric is reduced during the eclipse in the shadow of the Moon which therefore takes the role of a dielectric. For large values of  $c_{\#}$ , the gravitational contribution to  $g_{tt}$  is negligible and  $c_{\#}$  makes itself physically visible. The gravitational force as a gradient of the gravitational potential is not affected and explains the absence of longitudinal effects. The fluctuations of  $c_{\#}$  at the transition zone would explain the fluctuations of the pendulum frequency proportional to  $\sqrt{c_{\#}}$ .
2. Gravitational waves are transversal and could explain the transversal effects. The large value of gravitational Planck constant  $\hbar_{gr}$  could make the gravitational pendulum an extremely sensitive detector of gravitational waves.

Due to the large value of  $\hbar_{gr}$  and  $c_{\#}$ , reflection and refraction of the gravitational waves from the pendulum could have large effects during the transitions. Dark gravitons with large  $\hbar_{gr}$  have large energy  $E = \hbar_{gr}f$  and momentum  $p = E/c_{\#}$ . During the transition periods large reflection angles make possible large transfers of transversal momentum and cause a large

change of the oscillation plane. The situation at the middle point of the shadow would be dominated by the ordinary gravitational force even if the value of  $c_{\#}$  fluctuates. No effective screening of the ordinary gravitational forces would take place.

### 5.3 Indications for continuous background isotropy

[ER3] Goodey et al [E8](see this) confirmed Allais's 24h 50min lunar periodicity with a statistical significance of  $p \leq 7.8 \times 10^{-6}$ . Pugach & Olenici (2012) [E12] (see this) observed anomalies during the eclipse that was not visible from their observation sites (440 km apart, the eclipse visible only in the Indian Ocean). Both point to a continuous, non-local anisotropy of space that is only amplified by the eclipse.

The observed effects from different observation sites were correlated and lasted the time about 12 hours the lunar shadow was passing the Earth. Therefore effects appear also outside the shadow, which has radius slightly larger than the diameter of the Moon, which roughly one half of the Earth radius. The picture provided by geometric optics does not explain this.

[MP3] Both the classical hydrodynamical and quantum diffraction model for the gravitational interaction between the pendulum and gravitational fields of the Sun and Moon would predict that the effects appear in the scale of the entire Earth. The presence of wavelength 44 m supports the quantum diffraction model. On the other hand, the model explaining the Allais effect in transition zones does not need the diffraction picture.

## 6 Appendix: Some TGD background and questions

In the following I represent the general TGD background and questions.

### 6.1 General description of scattering

In the TGD, scattering events can be divided, in analogy with QCD, into transitions from the initial state (hadronic state) to the interaction state (formation of quark gluon-plasma) and then to the final state (hadronization).

1. Gravitons and various other bosons and fermions appear in the description of the initial and final states, which is in terms of the modes of the spinor fields of  $H = M^4 \times CP_2$ . The spacetime surface is not involved at this level. Color multiplets are associated with both quarks and leptons and an infinite hierarchy of scaled copies of the standard model is predicted.
2. In the interacting intermediate state, embedding space-coordinates define primary degrees of freedom. By general coordinate invariance there are only 4 of them. The classical theory obeying holography = holomorphy principle is an exact part of quantum TGD. This strongly suggests that classical description of interactions at space-time level is necessary. Electroweak degrees of freedom can be regarded as color degrees of freedom associated with the  $CP_2$  spin degrees of freedom. Also gravitational waves are induced and not primary. This strongly suggests a dramatic simplification of the description of gravitational and gauge interactions.
3. In TGD, fermionic vertices are basically analogous to standard model vertices represented as 3-D singular surfaces at which imbedding space coordinates have discontinuous derivative modulated by the presence of the induced metric. The gravitational contribution to the fermionic vertices would be a part of electroweak due to the contribution of the  $CP_2$  metric to the induced metric: intuitively it is clear that this should be related to gravitations.

It would seem fermionic electroweak vertices and the possibility of very large values of  $h_{gr}$  making possible long range quantum coherence for electroweak fields, are enough in the description of the fermionic degrees of freedom based on the TGD counterpart of quark-gluon plasma phase. There would be no need to include gravitons at this level. Various final state particles, including gravitons would appear only in the transition to the final states analogous to hadronization. This forces us to ask whether it is possible to talk about something analogous to graviton propagator?

4. In the recent view only the propagators for fundamental fermions are needed in the fermionic sector and the N-point functions for the spinor fields of "world of classical worlds" in the geometric degrees of freedom would emerge from the functional integral over WCW.

## 6.2 Some zero energy ontology

To understand the proposed model for the large value of  $\Delta f/f$  some zero energy ontology (ZEO) forming the basis of the TGD inspired quantum measurement theory is needed.

1. The basic entity in ZEO is causal diamond  $CD = cd \times CP_2$ , where  $cd$  is causal diamond of  $M^4$  defined as an intersection of future and past directed light-cones.  $cd$  is analogous to an empty cosmology with a big bang followed by a big crunch.  $CD$  has interpretation as the analog of the perceptive field of a conscious observer containing space-time surfaces or their restrictions.

The Lorentz invariant light-cone proper time  $a$  analogous to cosmic time defines a natural time coordinate so that the  $cd$  projections of 3-surfaces are intersections of the space-time surface with  $a = constant$  3-D hyperboloids of the second half-cone of the  $cd$ .

2. In TGD inspired cosmology energy and momentum are conserved, and the cosmic redshift could be seen as a problem. In TGD, the cosmic redshift is not caused by the tiring of light but is almost completely a kinematical effect due to the different orientations of 3-D tangent spaces of the 3-surfaces associated with the observer and source. The different orientations of tangent spaces are caused by the cosmic expansion which in TGD framework is mostly to the cosmic expansion associated with the  $a = constant$  hyperboloid of the  $cd$  associated with cosmology.

Could the unexpectedly large reduction of the frequency in Allais effect be due to the different orientations of  $cd$ s of the observer and pendulum characterized by a relative velocity parameter  $\beta_0$  distinguishing between  $cd$ s defining the perceptive fields of the observer and pendulum?

3. The moduli space  $M$  of  $cd$ s includes besides scalings also Poincare transformations mapping the passive boundary of  $cd$  (PB) to itself but acting non-trivially on  $cd$  as whole. Small state function reductions (SSFRs), identifiable as the TGD counterparts of repeated quantum measurements in standard QM, leave PB and the 3-D fermion states at it invariant (Zeno effect) but affect the active boundary of  $cd$  (AP) and states at it. The sequence of SSFRs defines self as a conscious entity.

A given SSFR is preceded by a unitary evolution implying delocalization in the moduli space  $M$  of  $cd$ s and SSFR induces a localization in  $M$ . SSFRs induce only a scaling of the PB leaving by the generalized conformal invariance the 3-D fermionic quantum states at it invariant. Lorentz transformations of the  $cd$  leaving PB invariant are possible but act non-trivially in  $M$  since they do not leave AP invariant.

## 6.3 Questions

### 6.3.1 Questions about gravitational interactions

There are questions related to the TGD description of gravitational interactions.

1. Both color interactions and gravitation couple to conserved isometry charges. This suggests that the situation is completely symmetric between gravitation and color interaction. Are also the gravitational interactions are induced by the presence of the induced metric in the couplings of the induced spinor fields to the electroweak gauge potentials? Somehow the space-time description of gravitational interactions should allow to distinguish them from gauge interactions. Does the distinction emerge only when the free quarks and leptons in the interacting state organized to final state particle giving rise also to gravitons?
2. Gravitational interactions cannot reduce to electroweak gauge forces. Gravitons and actually all elementary particle do emerge from fundamental fermions.

Also gravitational interaction should emerge somehow. Hadrons and also quarks and leptons emerge as geometric objects identifiable as closed monopole flux tube structures behaving like string like objects. Could gravitational interactions at the fundamental level emerge in the same way and be mediated by gravitational monopole flux tubes.

3. Einsteinian gravitation approximately reduces to a  $U(1)$  force and one can speak of Newtonian gravitation as the analog of electric force and also of gravimagnetism. The genuine reduction of gravitation to electroweak forces is not possible. One would have repulsion instead of attraction whereas matter and antimatter have repulsive gravitational force. It is now known and that antihydrogen falls down in the gravitational field of the Earth.
4. Hamilton-Jacobi (H-J) structure as a generalization of the Kähler structure for the causal diamond (cd) of  $M^4$  and consistent with  $M^4$  metric is degenerate in the sense that Kähler form is non-trivial only in the transversal degrees of freedom parametrized by a complex coordinate and trivial in the longitudinal degrees of freedom. What is the role of  $M^4$  H-J structure concerning gravitational interaction? Does also  $M^4$  Kähler form contribute to gravitation? Also the cd Kähler form is also of monopole type in the sense that it has non-trivial homology. Now it is due to the fact that cd has hole along the axis connecting its tips.

### 6.3.2 A more precise identification of basic objects

A precise identification of the basic objects such as flux tubes and massless extremals is needed.

1. What is the precise identification of the closed monopole flux tubes? One can consider single-sheeted closed monopole flux tubes whereas elementary particles and hadrons correspond to two-sheeted monopole flux tubes involving two wormhole contacts between them. Could also gravitational monopole flux tubes and "massless" extremals mediating interactions be such 2-sheeted structures.
2. What are the TGD counterparts of virtual particles are? Is it possible to construct them from the solutions of classical field equations satisfying holography= holomorphy correspondence? Could the light-like momenta associated with the sheets of a pair of parallel MEs be different so that they could be responsible for a transfer of momentum and could serve as TGD counterparts of virtual momenta transferred in interactions.

How does the attractive character of gravitation concretely emerge? Graviton is a spin 2 particle, formally a pair of spin 1 bosons. Could one see gravitons as pairs of  $U(1)$  bosons? Could gravitons be described in terms of MEs consisting of a pair of parallel space-time sheets carrying massless modes? Could the MEs of virtual gravitons carry light-like momenta which are not parallel? This brings in mind the proposal that gravitation could be seen as a square of a gauge theory.

### 6.3.3 Questions related to the notion of effective Planck constant

There are also questions related to the effective Planck constant.

1. The increase of  $h_{eff}$  to a large enough value guarantees that perturbation theory applies ("Mother Nature loves her theoreticians" [L1]). If this is indeed the case, the lowest order contribution to the scattering amplitude is independent of the Planck constant.

Therefore the large size of the Allais effect could reflect the large value of gravitational Compton length: there would be a large scale constructive interference impossible in standard model.

2. The increase of  $h_{eff}$  increases the size of quantum coherence region for all gauge interactions and quantum gravitation. In particular, this should be the case at the gravitational monopole flux tubes.

The notion of induced gauge field makes possible also the presence of color interactions in very long scales, even astrophysical scales since color interactions at the level of induced spinor fields reduce to electroweak interactions since the electroweak group  $SU(2)_w$  is a subgroup of the color group.

### 6.3.4 Questions related to the identification of fundamental interactions as contact interactions

The proposal is that fundamental interactions are contact interactions. Holography = holomorphy principle implies that the interactions between space-time sheets analogous to Bohr orbits are associated with their intersection giving rise to string world sheets. The magnetic monopole flux tubes are candidates for the mediators of long range interactions.

1. Could gravitational mass as Newtonian gravitational flux, using Planck mass or  $CP_2$  mass as a unit, be identifiable as Kähler magnetic monopole flux? If so, the gravitational mass would be a multiple of the basic unit of monopole flux. In the case of quarks, the Kähler charge is not integer. Does color quantum relate to this somehow.
2. Could gravitational coupling strength  $GMm$  reduce as a coupling between Kähler magnetic monopole fluxes associated with the 2-D intersections of the flux tubes consisting of string world sheets? Is this true for all couplings? Does  $\hbar/G_N$  or  $1/R^2$  correspond to string tension and is therefore much smaller for non-gravitational strings, which are much thicker if their radius correspond to p-adic length scale.
3. The TGD view about the cosmic evolution relies the p-adic variants of function fields allowing to understand the p-adic length scale hypothesis. Holography = holomorphy vision allows an exact solution of field equations. Evolution is essentially increase of algebraic complexity. One must distinguish between hierarchies of p-adic length scales and Planck constants. This means two closely related evolutions. Why  $G$  appears in gravitational interactions instead of  $R^2$  and string tension in hadronic interactions? Could the flux tubes in the case of gravitational interactions be cosmic strings with a minimal p-adic length scale associated with  $p = 2$ ?
4. Is the real  $CP_2$  radius equal to Planck length  $l_G$  for the minimal value of  $h = h_0$  and is the radius  $R$  equal to its scaled version with  $h = (7!)^2 h_0$ ?
5. Are also the gauge couplings associated with the electric gauge fluxes assignable with the intersections of monopole flux tubes? What about the exponents of the electric type fluxes associated with the string world sheets defining non-integrable phase factors, bringing to mind gauge theory formulation of the scattering amplitudes in terms of the string world sheets.
6. How to understand the notions of electric and gravitational Planck constant at the deeper level? Here I have proposed that Yangian algebras as involving polylocal generators might allow to understand them.

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