Anomalies Related to the Classical Z^0 Force and Gravitation

M. Pitkänen,

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

Contents

Abstract

TGD based concept of space-time predicts several new effects.

1. The dark matter associated with rotating macroscopic objects could generate classical Z^0 magnetic fields and this suggests that the behavior of rotating objects could exhibit anomalies. A special signature of effects of this kind is parity breaking caused by the parity breaking couplings of the classical Z^0 field to dark matter. The Z^0 electric fields generated by astrophysical bodies are predicted to be completely negligible as compared to gravitational fields but the topological light rays carrying Z^0 fields could induce interactions over astrophysical distances. Z^0 fields in length scale below cell size are predicted to be quite strong as compared to gravitation.
2. The recent view about fermionic fields [?] leads to the view that the well-definedness of em charge for spinor modes requires that the modes are localized at 2-D surfaces in the generic situation. It is quite possible that this localization is consistent with Kähler-Dirac equation only in the Minkowskian regions where the effective metric defined by Kähler-Dirac gamma matrices can be effectively 2-dimensional and parallel to string world sheet. A natural further assumption is that also classical Z^0 field vanishes at these 2-surfaces above weak scale at least. This would exclude classical Z^0 fields effectively since fermions would not couple to classical electroweak fields above weak scale. If the hierarchy of dark matter is realized, the weak scale could be however arbitrary long and situation would change. The large parity breaking effects in living matter suggest that this might be the case. This gives motivation for this chapter.
3. The mere rotation of a 3-surface carrying magnetic or Z^0 magnetic fields should induce electric or Z^0 electric fields whose divergence gives rise to vacuum charge density. Charge conservation suggests that this gauge flux must flow to a second space-time sheet carrying opposite net charge.
4. In TGD the time orientation of given space-time sheet need not be the standard one and this allows the possibility of negative classical energies. If this kind of space-time sheets are created, energy production with apparent efficiency greater than unity becomes possible. At the space-time sheets with negative time orientations classical fields should propagate from future to past making in principle possible to see to the geometric future of, say, astrophysical objects. Amazingly, the highly science fictive notion of negative energy space-time sheet finds support from the basic classical physics. The total energy associated with the topological field quanta emitted by particle a condensed to larger space-time sheets is the natural geometric correlate of potential energy. Potential energy can be negative only if one allows also negative energy space-time sheets.

   With the advent of zero energy ontology (ZEO) the notion of negative energy space-time sheet has become more well-defined. For instance, phase conjugate laser beams could have description as negative energy space-time sheets for which the arrow of time would be non-standard at quantum level.
5. A further TGD based element is related to the fact that 3-surface can be regarded as a generalization of point like particle. This means that 3-surface behaves like single coherent whole: in particular, classical fields oscillating coherently in arbitrary long length scales are possible and can give rise to an apparent propagation of effects with infinite velocity. The notion of pair creation from vacuum generalizes. For instance, pairs of space-time sheets with vanishing total classical energy can be created from vacuum.

1. Some gravitational anomalies

1. TGD predicts the possibility of anomalously large time dilation effects due to the warping of space-time surfaces, and the experimental findings of Russian physicist Chernobrov about anomalous changes in the rate of flow of time provide indirect support for this prediction.
2. There are quite puzzling observations related to the behavior of rotating stars. These observations are in a dramatic conflict with the standard wisdom about finite propagation velocity of signals and with the idea that classical fields propagate in future direction only. The possibility of space-time sheets with negative time orientation and classical fields propagating from geometric future to geometric past plus the possibility that 3-surfaces of even astrophysical size can behave like particle like objects, could explain these mysterious effects.

2. Anomalies possibly related to Z^0 force in astrophysical length scales

1. Allais observed that the oscillation plane of Foucault pendulum changes during solar eclipse. NASA performed the same experiment during 1999 eclipse but the processing of the data is still going on. The presence of moon could cause a modification of dark Z^0 laser beams emitted by Sun as synchrotron radiation and modify the contribution of Z^0 electric field to Z^0 force experienced by dark matter component of the pendulum. The effect is predicted to be observed only in the shadow of Moon created by Sun. Allais has observed also 24 and 25 hour periodicities in the oscillation of Foucault pendulum can be understood in terms of Earth's modification and the lengthening of the period associated with the Moon's screening due to the rotational motion of Moon around Earth.
2. Shnoll has shown that the rate distributions for radio active decays and chemical and biochemical processes do not converge to single bell curve but to distributions which have several pronounced peaks. The shapes of the rate curves seem to be similar for widely different reactions (radio-active decays, chemical and biochemical processes) but they fluctuate with time and fluctuation periods correspond to various astrophysical periods: day, month, year,... These anomalies might be understood if astrophysical objects emit Z^0 topological light rays interacting with ordinary matter (recall that already nuclei involve dark matter component).
3. p-Adic fractality predicts that dark Z^0 force could become comparable with the gravitational force in cell length scale. Tests of the Newtonian form of gravitational force are recently carried out in length scales 100 μm. There are anomalously large differences related to the measured values of gravitational constant using Cavendish type experiments or their variants. In the classical Cavendish experiment Z^0 force is effectively eliminated so that most of these discrepancies could be caused by the redistribution of the gravitational flux between space-time sheets.

1 Introduction

The topic of this chapter are new physics effects related to long ranged Z^0 force, more generally weak forces, and gravitation in TGD Universe. Before summarizing these effects it is useful to sum up the basic interpretation of long ranged weak fields as space-time correlates of dark matter.

1.1 TGD Based View About Dark Matter

TGD suggests an explanation of dark matter as a macroscopically quantum coherent phase residing at larger space-time sheets [K2].

1. TGD suggests that $\hbar$ is dynamical and possesses a spectrum expressible as integer multiples of the ordinary Planck constant. For large values of $\hbar$ macroscopic quantum phases are possible. The criterion for transition to large $\hbar$ phase is the failure of perturbative expansion so that Mother Nature takes care of the problems of theoretician. A good guess is that the criticality condition reads as $Q_1Q_2\alpha \simeq 1$ where Q_i are gauge charges and α gauge coupling strength. This leads to universal properties of the large $\hbar$ phase. For instance, $\hbar$ is scaled in the transition to dark phase by a harmonic or subharmonic of parameter $1/v_0 \simeq 2^{11}$ which is essentially the ratio of CP_2 length scale and Planck length [K12, K2]. The criticality condition can be applied also to dark matter itself and entire hierarchy of dark matters is predicted corresponding to the spectrum of values of $\hbar$.

2. An infinite hierarchy of dark matters is predicted [K5]. Direct interactions occur only between the particles characterized by integers having common p-adic prime factors characterizing the p-adic length scales of bosons exchanged in the interaction. The algebraic extensions of p-adic numbers define an additional hierarchy. Also the notion of darkness must be refined by attributes partial and relative.

3. From the point of view of nuclear physics application of this hypothesis is to QCD. The prediction is that the electromagnetic Compton sizes of dark quarks are scaled from $L_e(107)$ to about $2^{11}L_e(107) = L_e(129) = 2L_e(127)$, which is larger than the p-adic electromagnetic size of electron! The classical scattering cross sections are not changed but changes the

geometric sizes of dark quarks, hadrons, and nuclei. The original hypothesis that ordinary valence quarks are dark whereas sea quarks correspond to ordinary value of $\hbar$ is taken as a starting point. In accordance with the earlier model, nucleons in atomic nuclei are assumed to be accompanied by color bonds connecting exotic quark and anti-quark characterized p-adic length scale $L_e(127)$ with ordinary value of $\hbar$ and having thus scaled down mass of order MeV. The strong binding would be due the color bonds having exotic quark and anti-quark at their ends.

4. Quantum classical correspondence suggests that classical long ranged electro-weak gauge fields serve as classical space-time correlates for dark electro-weak gauge bosons, which are massless below the appropriate weak length scale L_w. This hypothesis could explain the special properties of bio-matter, in particular the chiral selection as resulting from the coupling to dark Z^0 quanta. Long range weak forces present in TGD counterpart of Higgs=0 phase should allow to understand the differences between biochemistry and the chemistry of dead matter.

5. For ordinary condensed matter quarks and leptons Z^0 charge are screened in electro-weak length scale whereas in dark matter $k = 89$ electro-weak space-time sheet have suffered a phase transition to a p-adic topology with a larger value of k. Gaussian Mersennes, in particular those associated with $k = 113, 151, 157, 163, 167$ are excellent candidates in this respect. The particles of this exotic phase of matter would have complex conformal weights closely related to the zeros of Riemann Zeta. The simplest possibility is that they correspond to a single non-trivial zero of Zeta and there is infinite hierarchy of particles of this kind.

   In dark matter phase weak gauge fluxes could be feeded to say $k = k_Z = 169$ space-time sheet corresponding to neutrino Compton length and having size of cell. For this scenario to make sense it is essential that p-adic thermodynamics predicts for dark quarks and leptons essentially the same masses as for their ordinary counterparts [K8].

1.2 New Physics Effects Related To The New Space-Time Concept

TGD based concept of space-time predicts several new effects.

1. The dark matter associated with rotating macroscopic objects should generate Z^0 magnetic fields and this suggests that the behavior of rotating objects should exhibit anomalies. A special signature of effects of this kind is parity breaking caused by the parity breaking couplings of the classical Z^0 field to dark matter. The Z^0 electric fields generated by astrophysical bodies are predicted to be completely negligible as compared to gravitational fields but the topological light rays carrying Z^0 fields could induce interactions over astrophysical distances. Z^0 fields in length scale below cell size are predicted to be quite strong as compared to gravitation.

2. The mere rotation of a 3-surface carrying magnetic or Z^0 magnetic fields should induce electric or Z^0 electric fields whose divergence gives rise to vacuum charge density. Charge conservation suggests that this gauge flux must flow to a second space-time sheet carrying opposite net charge.

3. In TGD the time orientation of given space-time sheet need not be the standard one and this allows the possibility of negative classical energies. If this kind of space-time sheets are created, energy production with apparent efficiency greater than unity becomes possible by time mirror mechanism [K15]. At the space-time sheets with negative time orientations classical fields should propagate from future to past making in principle possible to see to the geometric future of, say, astrophysical objects. Amazingly, the highly science fictive notion of negative energy space-time sheet finds support from the basic classical physics. The total energy associated with the topological field quanta emitted by particle and condensed to larger space-time sheets is the natural geometric correlate of potential energy. Potential energy can be negative only if one allows also negative energy space-time sheets.

4. A further TGD based element is related to the fact that 3-surface can be regarded as a generalization of a point like particle. This means that 3-surface behaves like single coherent

whole: in particular, classical fields oscillating coherently in arbitrary long length scales are possible and can give rise to an apparent propagation of effects with infinite velocity. The notion of pair creation from vacuum generalizes. For instance, pairs of space-time sheets with vanishing total classical energy can be created from vacuum.

1.3 Some Gravitational Anomalies

1. TGD predicts the possibility of anomalously large time dilation effects due to the warping of space-time surfaces, and the experimental findings of Russian physicist Chernobrov about anomalous changes in the rate of flow of time [J3, J1] provide indirect support for this prediction.

2. There are quite puzzling observations related to the behavior of rotating stars [H10]. These observations are in a dramatic conflict with the standard wisdom about finite propagation velocity of signals and with the idea that classical fields propagate in future direction only. The possibility of space-time sheets with negative time orientation and classical fields propagating from geometric future to geometric past plus the possibility that 3-surfaces of even astrophysical size can behave like particle like objects, could explain these mysterious effects.

1.4 Anomalies Related To Z^0 Force In Astrophysical Length Scales

Allais [E3, E10, E13, E14] observed that the oscillation plane of paraconic pendulum changes during solar eclipse. NASA performed the same experiment during 1999 eclipse but the processing of the data is still going on. The presence of moon could cause a modification of dark Z^0 laser beams emitted by Sun as synchrotron radiation and modify the contribution of Z^0 electric field to Z^0 force experienced by dark matter component of the pendulum. The effect is predicted to be observed only in the shadow of Moon created by Sun. Allais has observed also 24 and 25 hour periodicities in the oscillation of Foucault pendulum can be understood in terms of Earth's modification and the lengthening of the period associated with the Moon's screening due to the rotational motion of Moon around Earth.

Shnoll [E8]. [E8] has demonstrated that the rate distributions for radio active decays and chemical and biochemical processes do not converge to single bell curve as suggested by quantum randomness plus standard model but to distributions which have several pronounced peaks. The shapes of the rate curves seem to be similar for widely different reactions (radio-active decays, chemical and biochemical processes) but they fluctuate with time and fluctuation periods correspond to various astrophysical periods: day, month, year,... These anomalies can be also understood if astrophysical objects emit Z^0 topological light rays interacting with ordinary matter (recall that already nuclei involve dark matter component).

p-Adic fractality predicts that dark Z^0 force should become comparable with the gravitational force in cell length scale. Tests of the Newtonian form of gravitational force are recently carried out in length scales 100 μm. There are anomalously large differences related to the measured values of gravitational constant using Cavendish type experiments or their variants. In the classical Cavendish experiment Z^0 force is effectively eliminated so that most of these discrepancies could be caused by the redistribution of the gravitational flux between space-time sheets.

1.5 Anomalies Related To Rotating Systems

If ordinary condensed matter involves a dark matter component generating long range Z^0 fields, one expects that rotating systems generate Z^0 magnetic fields. Spinning systems represent a spectrum of anomalies involving parity breaking. Hence the natural guess is that long ranged weak magnetic fields might be an essential aspect of the phenomenon. Rotating magnetic systems (Searl device) [H13]. the N-machine of DePalma [H3] and the space-energy generator of [H1] [H1]. Podkletnov effect [H12]. and Modanese-Podkletnov effect [H11] represent examples about situations in which long range Z^0 forces seem to be of importance. Since also other key mechanisms are involved, the discussion of these effects is left to the chapter "The Notion of Free Energy and Many-Sheeted Space-Time Concept" [K15].

I have emphasized that this and the two next chapters reflect the development of ideas and are a collection of pages of a lab notebook rather than a final summary. After the revolution induced by the ideas about dark matter and interpretation of long ranged electro-weak and color gauge fields a dramatic convergence has however occurred: the latest updating reduced the number of pages roughly by a factor of two and most alternative new physics explanations for various effects could be dropped from consideration. To my humble opinion, also the continual cumulation of anomalies understood in TGD framework gives convincing support for the TGD view. In view of the potential technological implications it is highly regrettable that the academic community has missed the boat so completely. There is however some light at the end of tunnel. The number of people working with competing theories of quantum gravitation and admitting that these approaches are in grave difficulties is steadily increasing.

The appendix of the book gives a summary about basic concepts of TGD with illustrations. Pdf representation of same files serving as a kind of glossary can be found at `http://tgdtheory.fi/tgdglossary.pdf` [?].

2 The New View About Inertial And Gravitational Energy

TGD predicts the possibility of negative energy space-time sheets and phase conjugate photons can be identified as negative energy photons. If photons with negative energies are allowed, it is difficult to deny the possibility of fermions with negative energies. The possibility of having both signs of energy suggests an elegant solution to the problem of matter-antimatter asymmetry and a powerful new energy technology.

1. The standard second quantization of Dirac spinors postulates that ground state is annihilated by annihilation operators for fermions and anti-fermions. One can construct explicitly the state annihilated by annihilation operators. Suppose that there is state which is not annihilated by any annihilation operator and apply the product of all annihilation operators to this state. Electrons and positrons represent holes in this sea and are created by applying creation operators. The states have positive energy with respect to the ground state. The aesthetic problem of this quantization is that ground state has an infinitely high negative energy.

2. In TGD framework one could change the role of creation and annihilation operators so that the ground state would be obtained by applying the product of all creation operators to vacuum. This state would have infinite positive energy. Fermions and anti-fermions would be holes in Dirac sea of positive energy and behave as negative energy quanta. One might expect that these two quantizations correspond to two different time orientations for the space-time surface.

2.1 Two ways To Circumvent The Infinite Vacuum Energy

The infinite vacuum energy is definitely something very unsatisfactory, and one should overcome this problem somehow. The most elegant and predictive variant of TGD inspired cosmology assumes that the net energy of the Universe vanishes so that the universe could have been created intentionally from vacuum (and be created again and again in each quantum jump). The vanishing of the total energy follows automatically if one poses the condition that the energy flow through the light cone boundary ($H = M^4_+ \times CP_2$) vanishes. This requires that also fermionic vacuum energies cancel each other. There are two ways to achieve the cancellation.

1. If positive and negative energy space-time sheets are always created in a pairwise manner their vacuum energies could compensate each other, at least so if some additional conditions are satisfied. The success of elementary particle physics requires that this mechanism is at work in elementary particle length scales.

2. Vacuum energies could also cancel each other for each space-time sheet separately. This is achieved if the roles of creation and annihilation operators for either fermions or anti-fermions are exchanged. This implies automatically matter antimatter asymmetry since either fermions or anti-fermions would have negative energies. This option could be realized in long length scales and explain the absence of antimatter from the Universe as absence

of positive energy antimatter. It would thus seem that all four ground states states are in principle possible and that the ground state characterizes the phase of matter.

2.2 Zero Energy Vacuum Is Matter-Antimatter Asymmetric

Consider now in more detail the latter option 2) assuming for definiteness that it is anti-fermions for which the roles of creation and annihilation operators are exchanged. The ground state is obtained by applying the product of all fermion annihilation operators and anti-fermion creation operators to vacuum. Fermions represent holes in a completely filled negative energy Dirac sea and have positive energy. Anti-fermions represent holes in positive energy Dirac sea and have thus negative energy. In this ground state annihilation of photon pair is possible only to an fermion with positive and anti-fermion with negative energy.

Obviously the state is matter-antimatter asymmetric since anti-fermions cannot appear as positive energy holes. Negative energy antimatter could be present but could have remained invisible. For instance, Pauli Exclusion Principle would make the scattering of negative energy anti-fermions impossible in the case that there are not sufficiently many holes in the sea. The same occurs for condensed matter electrons below the surface of the Fermi sphere. Even in the case that negative energy anti-fermions are present abundantly, they might have escaped detection. Due to the prevailing dogmas, no-one has tried to detect signatures for the scattering of negative energy anti-fermions or two photon annihilation to a pair of positive energy fermion and negative energy anti-fermion.

2.3 Creation Of Matter From Vacuum By Annihilation Of Laser Waves And Their Phase Conjugates?

The possibility of negative energy anti-fermions suggests a new energy technology. Photons and their phase conjugates with opposite energies could only annihilate to a pair of positive energy fermion and negative energy anti-fermion. Vacuum could effectively serve as an unlimited source of positive energy and make creation of matter from nothing literally possible. The idea could be tested by allowing laser beams and their phase conjugates to interact and by looking whether fermions pop out via two-photon annihilation. Fermion-anti-fermion pairs with arbitrarily large fermion masses could be generated by utilizing photons of arbitrarily low energy. The energies of the final state fermion is completely fixed from conservation laws so that it should be relatively easy to check whether the process really occurs. Generalized Feynman rules predict the cross section for the process and it should behave as $\sigma \propto \alpha^2/m^2$, where m is the mass of the fermion so that annihilation to electrons is the best candidate for study. Bio-systems might have already invented intentional generation of matter in this manner. Certainly the possible new energy technology should be applied with some caution in order to not to build a new quasar!

2.4 Re-Interpretation Of TGD Inspired Cosmology

The proposed hypothesis challenges the basic interpretation of the TGD based cosmology [K1, K13] is derived from the consistency with General Relativity. The basic interpretational problem of TGD inspired cosmology has been that Robertson-Walker cosmologies represent vacuum extremals of the Kähler action. Einstein's equations are used to define the energy density of the cosmology. This is admittedly somewhat ad hoc procedure but forced by the Equivalence Principle and positivity of inertial masses.

The possibility of negative inertial masses leads to a profoundly new kind of interpretation of cosmology based on the hypothesis that gravitational mass is the absolute value of the inertial mass.

1. Vacuum property of R-W cosmologies means that negative and positive inertial energy densities cancel each other in the cosmological length scales. Gravitational mass represents the absolute value of the inertial mass so that Einstein tensor corresponds to the difference of the positive energy momentum current associated with matter and the negative energy momentum current antimatter (in the phase in which anti-fermions have negative energies). These currents are indeed uniquely defined in TGD Universe. The basic equations of the standard

cosmology survive as such. If gravitational mass had the sign of the inertial mass, there would be a repulsion between matter and antimatter and the basic equations for cosmology would be altered dramatically: this looks implausible.

2. The fact that Einstein tensor is a tensor quantity whereas inertial mass density is a component of a vector field, favors strongly the new interpretation. The strong non-conservation of gravitational mass during early cosmology is not anymore inconsistent with Poincare invariance. Although the explanation for the non-conservation of the inertial mass in terms of a mass transfer between different space-time sheet becomes obsolete, the models for asymptotic cosmology and asymptotic evolution of star still make sense. The interpretation in terms of the conservation of gravitational mass resulting from the separate conservation of matter and antimatter energy densities since the annihilation of matter and antimatter and the reverse of this process do not occur appreciably anymore.

3. The mysterious vacuum extremals quite generally represent matter-antimatter symmetric states whereas non-vacuum extremals are by definition matter-antimatter asymmetric with the density of Kähler field energy identifiable as the net inertial energy density. This gives very strong grasp to the interpretation and technological application of the theory. In particular, highly curved vacuum extremals represent high energy densities of matter and antimatter, and the generation of this kind of space-time sheets followed by a generation of Kähler fields represent a creation of matter and antimatter from vacuum followed by the emission of particles or anti particles inducing the Kähler field. This would make possible a genuine engineering of the Universe.

The new view changes dramatically the interpretation of the early periods of cosmology although the basic equations for the density of gravitational mass are not changed.

1. Since cosmic strings are not vacuum extremals, they could represent a phase in which fermions and positrons have the same sign of energy, that is the phase of standard quantum field theories. The creation of the Universe from vacuum would mean generation of cosmic strings of opposite time orientations from vacuum during the first moments of cosmology. I have used the notion of "wormhole magnetic field" about pairs of space-time sheets carrying magnetic fields in opposite directions and having opposite time orientations [K17]. This terminology would be appropriate also now.

2. The topological condensation of cosmic strings to the background space-time sheets would induce a phase transition in which positive energy antimatter falls into negative energy states by emitting the difference energy as ordinary particles of positive or negative energy depending on the sign of time orientation. This process would replace the decay of the ends of split cosmic strings to elementary particles as a source of ordinary matter. Since Kähler magnetic flux is conserved in the process of thickening of the flux tubes, the magnetic energy density per unit length for topologically condensed cosmic strings decreases like $1/S$ (S is the area of cross section) in the process, and they become gradually magnetic or Z^0 magnetic flux tubes serving as templates for various structures. The emitted particles topologically condense at the background space-time and possess vanishing average inertial energy density in the length scales where cosmology applies.

   Critical cosmology naturally represents this phase transition, and the breaking of Lorentz symmetry can be interpreted as being caused by the seed of the phase transition located at $r = 0$. With the conventional interpretation for the Einstein tensor, the recent cosmology of course poses strong lower bounds on the sizes of these regions but with the new interpretation the separation of matter and antimatter corresponds to the breaking of the Cosmological Principle (Lorentz invariance) due to the presence of non-vanishing Kähler fields.

3. The obvious question is whether there is some scale in which the induced Kähler fields vanish or possibly an entire hierarchy of these scales corresponding to p-adic length scale hierarchy. The model for large voids involves a "big" cosmic string at the center of the void carrying a non-vanishing and very high density of Kähler magnetic energy and Kähler charge whereas the cosmic strings at the boundaries of void would carry opposite Kähler charge. Could

these two kinds of cosmic strings represent remnants of a primordial pair of cosmic strings with opposite time orientation? If this were the case, there would be a genuine separation of matter and antimatter in the scale of large voids.

4. The option for which gravitational masses have both signs, looks at first attractive because the gravitational repulsion between particles having gravitational masses of opposite sign could automatically lead to the separation of matter and antimatter containing regions. On the other hand, an antiparticle surrounded by matter would experience vanishing average acceleration so that the vanishing of energy density could occur in relatively short length scales.

One might even try to explain the observed acceleration of cosmic expansion in terms of this repulsion. p-Adic fractality however suggests an explanation as an apparent acceleration due to the fact that the average density of gravitational mass at larger space-time sheets representing longer p-adic length scales is lower, and the expansion occurs faster due to the weakening of the gravitational force. The notion of fractal energy density is somewhat questionable for a conserved inertial energy density in the presence of isotropy but makes sense for the density of the gravitational energy.

3 Some Gravitational Anomalies

In this section some exotic gravitational effects predicted by TGD are discussed. An infinite family of warped embeddings of say Scwartschild metric predicts the possibility of anomalous time dilation much larger than ordinary gravitational time dilation. There is indeed evidence for this kind of phenomenon [J3]. Second exotic effect would be antigravity effects due to the redistribution of the gravitational flux fed by system to larger space-time sheets. A third dramatic effect would be signals propagating in the direction of geometric past as negative energy signals. There is empirical evidence also for this effect [J2].

3.1 Anomalous Time Dilation Effects Due ToWarping As Basic Distinction Between TGD And GRT

TGD predicts the possibility of large anomalous time dilation effects due to the warping of space-time surfaces, and the experimental findings of Russian physicist Chernobrov about anomalous changes in the rate of flow of time [J3, J1] provide indirect support for this prediction.

3.1.1 Anomalous time dilation effect due to the warping

Consider first the ordinary gravitational time dilation predicted by GRT. For simplicity consider a stationary spherically symmetric metric $ds^2 = g_{tt}dt^2 - g_{rr}dr^2 - r^2d\Omega^2$ in spherical coordinates. The time dilation is characterized by the difference $\Delta = \sqrt{g_{tt}} - 1$. In the weak field approximation one has $g_{tt} = 1 + 2\Phi_{gr}$, where Φ_{gr} is gravitational potential. The ordinary time dilation is given by $\Delta = \sqrt{g_{tt}} - 1 \simeq 2\Phi_{gr}$. At the Earth's surface the gravitational potential of the Earth is about $\Phi_{gr} = GM/R_E \simeq 10^{-9}$.

Consider next the situation for space-time surfaces. There exists an infinite number of warped embeddings of M^4 to $M^4 \times CP_2$ given by $s^k = s^k(m^0)$, which are metrically equivalent with the canonical embedding with CP_2 coordinates constant. New M^4 time coordinate is related by a diffeomorphism to the standard one. By restricting the embedding to $M^4 \times S^1$, where S^1 a geodesic circle with radius $R/2$ (using the chosen convention for the definition CP_2 radius), the time component of the induced metric is $g_{m^0m^0} = 1 - R^2\omega^2/4$. The identification of M^4 coordinates as the preferred natural standard coordinate frame allows to overcome the difficulties related to the identification of the preferred time coordinate in general relativity in the case the metric does not approach asymptotically flat metric. For this choice an anomalous time dilation $\sqrt{1 - R^2\omega^2/4}$ due to the warping results even when gravitational fields are absent. Moreover, the dilation can be large.

The study of the embeddings of Scwhartshild metric as vacuum extremals [K16] demonstrates that this vacuum warping is also seen as the degeneracy of the embeddings of stationary spherically symmetric metrics. Denote the coordinates of M^4_+ by (m^0, r_M, θ, ϕ) and those of X^4 by (t, r_M, θ, ϕ). The expression for the Reissner-Nordström metric reads as

$$\begin{aligned} ds^2 &= Adt^2 - Bdr_M^2 - r_M^2 d\Omega^2 \ , \\ A &= 1 - \frac{a}{r_M} - \frac{b}{r_M^2} \ , \quad B = \frac{1}{A} \ , \\ a &= 2GM \ , \quad b = G\pi q^2 \ . \end{aligned} \tag{3.1}$$

The embedding is given by the expression

$$\begin{aligned} \Phi &= \omega_1 t + f(r_M) \ , \\ \Psi &= k\Phi = \omega_2 t + kf(r_M) \ , \\ m^0 &= \lambda t + h(r_M) \ , \\ \lambda &= \sqrt{1 + \frac{R^2\omega_1^2}{4} s^{eff}_{\Phi\Phi}(\infty)} \ , \quad k = \frac{\omega_2}{\omega_1} \ . \end{aligned} \tag{3.2}$$

The components of s^{eff} depend on vacuum extremal. For the embeddings to $M^4 \times S^2_{II}$, where S^2_{II} is homologically trivial geodesic sphere s_{eff} reduces to the metric $ds^2 = R^2 d\Omega^2/4$ of standard S^2.

The functions $f(r_M)$ and $h(r_M)$ are determined by the condition

$$\lambda \partial_{r_M} h = \frac{R^2}{4} s^{eff}_{\Phi\Phi} \omega_1 \partial_{r_M} f \tag{3.3}$$

resulting from the requirement $g_{tr_M} = 0$ and from the expression for $g_{r_M r_M} = -B$:

$$\begin{aligned} h &= \int dr_M \sqrt{Y} \ , \quad Y = \frac{Y_1}{Y_2} \ , \\ Y_1 &= -B + 1 + \frac{R^2}{4} s^{eff}_{\Theta\Theta} \frac{(\partial_{r_M} u)^2}{(1-u^2)} \ , \\ Y_2 &= 1 - \frac{4\lambda^2}{R^2\omega_1^2} \frac{s^{eff}_{\Theta\Theta}}{s^{eff}_{\Phi\Phi}} \ . \end{aligned} \tag{3.4}$$

The condition $g_{tt} = 1$ at infinite distance implies the condition

$$\lambda^2 - \frac{R^2\omega_1^2}{4} s^{eff}_{\Phi\Phi}(\infty) = 1 \ . \tag{3.5}$$

This condition fixes only the ratio λ/ω_1 so that a one-parameter family of analogs of warped embeddings results.

If m^0 is used as a time coordinate, anomalous time dilation is obtained also at $r_M \rightarrow \infty$ and is given by

$$\sqrt{g_{m^0m^0}} = \frac{1}{\lambda} \ . \tag{3.6}$$

This time dilation is seen only if the clocks to be compared are at different space-time sheets. The anomalous time dilation can be quite large since the order of magnitude for the parameter ωR is naturally of order one for the embeddings of R-N metrics [K16].

3.1.2 Mechanisms producing anomalous time dilation

Anomalous time dilation could result in many ways.

1. An adiabatic variation of the parameters λ and ω_1 of the space-time sheet containing the clock could be induced by some physical mechanism. For instance, X_c^4 could move "over" a large space-time sheet X^4 and gradually form $\#$ and $\#_B$ contacts with it. Topological light rays (MEs) define a good candidate for X^4. The parameter values λ and ω could change quasi-continuously if X_c^4 gradually generates CP_2 sized wormhole contacts or join along boundaries bonds/flux tubes connecting it to X^4. This process would not affect the gravitational flux fed to X_c^4.

   For instance, if X^4 is at rest with respect to Earth, this motion would result from the rotation of Earth and the effect should appear periodically from day to day. If it is at rest with respect to Sun, the effect should appear once a year.

   The generation of vacuum extremals X_{vac}^4 (not gravitational vacua), which is in principle possible even by intentional action since conservation laws are not broken, could induce anomalous time dilation by this mechanism.

2. A phase transition increasing the value of $\hbar$ increases the size of the space-time sheet in the same proportion. This transition could quite well affect also the parameter λ. If this phase transition occurs for the space-time sheet X_c^4 at which the clock feeds its gravitational flux, this mechanism could provide a feasible manner to induce an anomalous time dilation.

3. The system containing the clock could suffer a temporary topological condensation to a smaller space-time sheet and thus feed its gravitational flux to this space-time sheet. This would require coherently occurring splitting of # contacts and their regeneration. It is not possible to say anything definite about the probability of this kind of process except that it does not look very feasible.

3.1.3 The findings of Chernobrov

The findings claimed by Russian researcher V. Chernobrov support anomalous time dilation effect [J3, J1]. Chernobrov has studied anomalies in the rate of time flow defined operationally by comparing the readings of clocks enclosed inside a spherical volume with the readings of clocks outside this volume. The experimental apparatus involves a complex Russian doll like structure of electromagnets.

Chernobrov reports a slowing down of time by about 30 seconds per hour inside his experimental apparatus [J3] so that the average dilation factor during hour would be about $\Delta = 1/120$. If the dilation is present all the time, the anomalous contribution to the gravitational potential would be by a factor $\sim 10^7$ larger than that of Earth's gravitational potential and huge gravitational perturbations would be required to produce this kind of effect.

The slowing of the time flow is reported to occur gradually whereas the increase for the rate of time flow is reported to occur discontinuously. Time dilation effects were observed in connection with the cycles of moon, diurnal fluctuations, and even the presence of operator.

Consider now the explanation of the basic qualitative findings of Chernobrov.

1. The gradual slowing of the time flow suggests that the parameter values of λ and ω change adiabatically. This favors option 1) since the formation of # contacts occurs with some finite rate.

2. Also the sudden increase of the rate of time flow is consistent with option 1) since the splitting of # contacts occurs immediately when the sheets X_c^4 and X^4 are not "over" each other.

3. The occurrence of the effect in connection with the cycles of moon, diurnal fluctuations, and in the presence of operator support this interpretation. The last observation would support the view that intentional generation of almost vacuum space-time sheets is indeed possible.

3.1.4 Vacuum extremals as means of generating time dilation effects intentionally?

Field equations allow a gigantic family of vacuum extremals: any 4-surface having CP_2 projection, which belongs to a 2-dimensional Legendre manifold with a vanishing induced Kähler form, is a vacuum extremal. Canonical transformations and diffeomorphisms of CP_2 produce new vacuum extremals. Vacuum extremals carry non-vanishing classical electro-weak and color fields which are reduced to some $U(1)$ subgroup of the full gauge group and also classical gravitational field. Although the vacuum extremals are not absolute minima, their small deformations could define such. These vacuum extremals, call them X^4_{vac} for brevity, could be generated by intentional action. In the first quantum jump the p-adic variant of the vacuum extremal representing an intention to create X^4_{vac} would appear and in some subsequent quantum jump it would be transformed to a real space-time sheet.

The creation of these almost vacuum extremals could generate time dilation effects. The material system would gradually generate CP_2 sized wormhole contacts and/or join along boundaries/flux tubes connecting its space-time sheet to X^4_{vac} and this could change the values of the vacuum parameters λ, ω.

3.2 Anomalies Related To Spinning Astrophysical Objects

Kozyrev [H9] has conducted astronomical observations using a receiving system of a new type. These observations have been replicated later by other groups [H5].

1. When a telescope was directed at a certain star, the detector positioned within the telescope registered the incoming signal even if the main mirror of the telescope was shieded by metal screens. This indicated that electromagnetic waves were accompanied by some waves not shielded by the metal screens.

2. When the telescope was directed to the true position, the signal became stronger. As if there had been almost instantaneous propagation of signal with velocity billions times greater than the velocity of light.

3. When the telescope was directed to a position symmetrical with respect to visible position, again signal was detected: the imaginative interpretation was that the signal came from future position of the star!

Leaving aside the objections of a typical sceptic and the question whether the effect is real or not, one can ask whether the concepts of many-sheeted space-time concept and classical Z^0 field could somehow give rise to this kind of effect in strong conflict with conventional wisdom.

1. Very light dark gluons and electro-weak bosons (extremely tiny CP_2 type vacuum extremals glued to macroscopic space-time sheet) could have the propagating classical color and weak gauge fields, in particular Z^0 field, as a space-time correlate. This field can be said to cause the effect in the detector.

2. The strong signal from the true position could have explanation in terms of a coherent classical Z^0 field of astronomical size. This kind of coherence is forced by the imbeddability requirement and was coined as topological field quantization in [K7]. One can intuitively understand it as follows. In TGD elementary particle is replaced with 3-surface, which can have arbitrarily large size and absolution minimization of Kähler action forces 3-surface to behave coherently like single particle (in case that it does not so, it decomposes into disjoint components!).

   The results of Kozyrev are not the only evidence for this kind of behavior. Total eclipses of the Sun by the Moon reach maximum eclipse about 40 seconds before Sun's and Moon's gravitational forces on Earth align [H15]. If gravity is a propagating force, this 3-body test implies that gravity propagates at least 20 times faster than light. The result is consistent with the assumption that the acceleration of Earth is towards the true instantaneous direction of the Sun now, rather than being parallel to the direction of the arriving solar photons now. TGD based explanation is that the changes of the classical gravitational field are not propagating effects but that the classical gravitational field behaves like single coherent whole (it could of course contain also small propagating part).

3. The signal in the symmetric position could come from geometric future. Only classical gauge fields can carry this kind of signal. One possibility is that classical fields generated by astronomical object propagate in both future and past. A more attractive possibility is

that classical Z^0 field propagated along space-time sheet with negative time orientation: for negative time orientation the propagation is expected to occur backwards in time.

This picture is in accordance with the TGD based explanation for the poorly understood observations of Faraday, for the functioning of Searl machine [H13], and for the claim that the efficiency of DePalma generator [H3] and space energy generator of Tewari [H1] could be apparently larger than one. Thus a general pattern behind the anomalies seems to emerge.

1. The basic idea is that space-time sheets with negative time orientation have negative sign of classical energy: this follows solely from the assumption that space-time is 4-surface.

2. The rotating 3-surface associated with the rotating conductor carries vacuum charge density and charge conservation requires the presence of a space-time sheet with opposite sign of charge density. If the time orientation of this space-time sheet is negative, it has negative classical energy and energy conservation requires that material space-time sheet has correspondingly larger energy, which in principle makes possible energy production with apparent efficiency larger than one. The actual mechanism of energy gain would be however time mirror mechanism (see **Fig.** `http://tgdtheory.fi/appfigures/timemirror.jpg` or **Fig. ??** in the appendix of this book). The system generates negative energy bosons (phase conjugate laser beams having topological light rays as space-time correlates) received by another system analogous to a population inverted laser. A phase transition like transition to the round state is thus induced and strong beam of positive energy bosons is emitted and received by the sender of the negative energy signal. This mechanism is discussed in detail in the chapter "The Notion of Free Energy and Many-Sheeted Space-Time Concept" [K15].

3. Stars are rapidly rotating objects carrying magnetic and Z^0 magnetic fields and somewhat like scaled up versions of Searl machine and this suggests that vacuum charge density and space-time sheet with negative time orientation are generated also in this case.

4 Is Electro-Gravity Possible In TGD Framework?

The interpretation of the classical gravitational fields has been one of the messy parts of TGD.

1. When I started to develop TGD, the only reasonable guess was that they really correspond to the measured gravitational fields. There is however an objection against this interpretation. First of all, only a very limited repertoire of space-time metrics can be imbedded as induced metrics in $H = M^4_+ \times CP_2$. Already rotating black-hole metrics are impossible to imbed and embedding would require hundreds of embedding space dimensions in the general case.

2. Much later it became clear that all elementary particles, with gravitons included, correspond to CP_2 type extremals which are the TGD counterparts of strings (TGD of course allows also cosmic strings). The exchange of these gravitons gives rise to the gravitational interactions. The space-time metric of Einstein's general relativity is only the effective metric associated with coherent states of gravitons. Thus the classical gravitational field, and also classical gauge fields, seem to be something completely new, not encountered in theories in which particles are point like objects or strings. This interpretation resolves nicely the objection related to the imbeddability constraints.

3. A further step of progress came when I learned about the work of R. Y. Chiao about superconductors as transducers and antennas for gravitational and electromagnetic radiation [**?**]. The realization was that the non-relativistic limit for gravitational fields allowing to interpret Riemann connection as a Maxwellian field provides surprisingly good under understanding of the classical gravitation in TGD Universe and allows also a new model for Podkletnov effect. This work encouraged to take seriously the hypothesis that classical Kähler fields couples to classical gravitational field with a strength which is about $R^2/G \sim 10^7$ times stronger than ordinary gravitational coupling constant strength (R is CP_2 size). Skeptic would of course argue that the results represents a fatal internal inconsistency of the theory: CP_2 size must be given by Planck length. This however leads to non-sensible predictions. Now I agree with the skeptic.

4. The understanding of how GRT emerges from TGD as effective theory leads to the resolution of various mysteries revolving around the notion of energy and gravitational mass. GRT limit of TGD can be obtained as effective theory in which M^4 is endowed with an effective metric defined as sum of flat Minkowski metric and sum over the deviations of the effective metrics of various space-time sheets from flat metric. Similar description applies to various gauge fields. Classical form of Equivalence Principle reduces to its formulation in GRT. Newton's constant and cosmological constant follow as predictions.

   In particular, the puzzle of too large gravitational constant for non-vacuum embedding of Reissner Nordstr¨m metric (not preferred extremal) disappears since there is no reason to identify the effective metric as induced metric. If space-time becomes in asymptotic space-time regions single sheeted vacuum extremal having say R-N metric, it might make sense to identify the effective metric identified as induced metric.

4.1 Classical Gravitational Fields For Space-Time Surfaces For Which CP_2 Projection Corresponds To A Homologically Non-Trivial Geodesic Sphere

In the previous picture the genuinely classical gravitational fields represent a completely new form of gravitational interaction and it is obviously highly interesting to try to understand something about the character or this interaction.

1. The space-time surfaces representable as sub-manifolds of $M^4_+ \times S^2$, S^2 geodesic sphere of CP_2, are excellent testing ground for ideas. There are two kinds of geodesic spheres: the first one is homologically trivial and corresponds to a vacuum extremal for which induced Kähler form vanishes. Of course, any Legendre manifold Y^2 of CP_2 is as good as S^2 and the canonical transformations of CP_2 give an infinite variety of these manifolds. The second S^2 one is homologically nontrivial and for this induced Kähler form is non-vanishing. In both cases induced Abelian gauge fields are present and color rotations act as symmetries mixing classical em and Z^0 fields.

2. An especially interesting solution ansatz for S^2 is stationary solution ansatz. Standard linear M^4 coordinates (m^0, m^i) are the proper coordinates for X^4 in this case. For this ansatz the phase angle Φ of S^2 complex coordinate is linear in the time coordinate so that the induced metric and gauge fields do not depend on M^4 time m^0.

   $$\Phi = \omega m^0 + f(m^i) \ , \quad \Theta = \Theta(m^i) \ .$$

   By explicitly writing out the expressions for the components of the induced metric and gauge field involving time as index one has

   $$\begin{aligned} g_{00} &= 1 - (R^2/4)sin^2(\Theta)\omega^2 \ , \quad g_{0i} = (R^2/4)sin^2(\Theta)\omega\partial_i f \ . \\ F_{0i} &= ksin(\Theta)\omega\partial_i\Theta \ . \end{aligned} \tag{4.1}$$

   Here k is some numerical constant of order unity depending on the embedding (gauge field can be in any direction in the gauge algebra of electro-weak gauge group and only Kähler field is invariant in color rotations).

   If the spatial gradients of CP_2 coordinates satisfy the conditions $|\nabla\Theta| << \omega$ and $|\nabla\Phi| << \omega$, the deviations of g_{ij} from the flat 3-metric are small as compared to the components $g_{0\alpha}$, and one has what can be identified as a non-relativistic limit of the theory. Also the components of the magnetic field are small in consistency with the notion that magnetic fields are of order $O(v/c)$ as compared to electric fields in the non-relativistic limit.

   Of course, the solutions form an extremely restricted set: for instance, electric and magnetic field are orthogonal to each other. On the other hand, criticality of the preferred extremals of Kähler action in the sense of having an infinite number of deformations for which the second variation of Kähler action vanishes, is expected to select very limited set of field configurations and highly symmetric ones with electric field dominating are the favored ones. Preferred extremals is nothing but the analog of Bohr orbits in wave mechanism. The study of this limit is especially revealing concerning the interpretation of the classical gravitational fields.

3. In the non-relativistic limit Einstein's theory reduces effectively to a Maxwellian theory with $g_{00} \equiv \Phi_g$ taking the role of the scalar potential of the gravito-electric field and $g_{ti} \equiv A_i$ taking the role of the components of the vector potential. Christoffel symbols represent gravitoelectric and gravito-magnetic fields and the components $(G^{00}, G^{0i}) \equiv (J_g^0, J_g^i)$ of the Einstein tensor represent four current (charge density and 3-current). This interpretation provides a very attractive phenomenological manner to understand the non-relativistic limit of the theory. The natural interpretation is as a dimensional reduction in which the theory reduces to a 3-dimensional gravitational theory coupled to gravito-Maxwell field so that the energy momentum current (J_g^0, J_g^i) becomes a gauge current. If the interpretation is correct, then three-dimensional Einstein equations should be satisfied in the sense that G^{ij} can be interpreted as the canonical energy momentum tensor for the gravito-Maxwellian field. The fact that this tensor is quadratic in $\nabla\Theta$ is consistent with this.

4. One can calculate explicitly gravito-Maxwellian field and one finds

$$\begin{aligned} E_{g,i} &= \nabla_i g_{00} = (R^2\omega^2/2)cos(\Theta)\nabla_i cos(\Theta) \ , \\ B_{g,ij} &= (R^2\omega/2)cos(\Theta)\left[\nabla_i cos(\Theta)\nabla_j f - (i \leftrightarrow j)\right] \ . \end{aligned} \tag{4.2}$$

One can write the components of gravito-Maxwell fields in terms of the gauge potential components alone by noticing that the gauge potential ($F_{\mu\nu} = \nabla_\nu A_\mu - \nabla_\mu A_\nu$) for the ordinary $U(1)$ gauge field is given by

$$A_0 = \left[-cos(\Theta_0) + cos(\Theta)\right]\omega \ , \quad A_i = \left[-cos(\Theta_0) + cos(\Theta)\right]\nabla_i f \ . \tag{4.3}$$

Here $cos(\Theta_0) = -1$ holds true for a potential which is well defined around the south pole of S^2 and $cos(\Theta_0) = 1$ for a potential well-defined around the north pole (monopole field is in question). $cos(\Theta_0) = 0$ holds true for a potential defined in the region outside the northern and southern poles. The gravito-Maxwell fields are given by the expression

$$\begin{aligned} E_{g,i} &= (R^2/2)\left[A_0 + cos(\Theta_0)\omega\right]E_i \ , \\ B_{g,ij} &= (R^2/2)\left[A_0 + cos(\Theta_0)\omega\right]B_{ij} \ . \end{aligned} \tag{4.4}$$

The beautiful result is that gravito-Maxwell fields is related to the Maxwell field with a proportionality factor expressible in terms of the scalar potential. This finding gives strong support to the ideas about electro-gravity stating that classical electromagnetic fields are accompanied by strong gravitational fields. Note however that this result involves the assumption about coherence. If coherence is absent classical gauge fields and gravitational field can reside at different space-time sheets.

4.2 TGD Does Not Predict Anomalously Large Coupling Of Gravitation To Classical Gauge Fields

The explicit calculation of the components of the Einstein tensor in the non-relativistic approximation (charge density and 3-current associated with E_g and G_g) gives a very nice result. (G^{00}, G^{0i}) are proportional to the corresponding components of the canonical energy momentum tensor of the Maxwell field plus the interaction term with four current in case that E and B give rise to non-vanishing vacuum charge density and current: this is quite possible in TGD framework. A good guess is that the divergence of G^{ij} gives rise to the spatial components of the Maxwellian energy momentum tensor and that Maxwell-Einstein equations are identically satisfied.

The calculation of the Einstein tensor also demonstrates that under the assumption that Equivalence Principle holds true the value of the gravitational constant is given by

$$G_{cl} = R^2 g^2 = R^2 \times 4\pi \times \alpha \tag{4.5}$$

where $\alpha = g^2/4\pi$ represents the effective gauge coupling of the $U(1)$ gauge field in question. This coupling enters because the induced gauge potential is gA_μ rather than A_μ by definition so that energy momentum density is proportional to $1/g^2$. p-Adic mass calculations fix the value of R^2 from electron mass scale and also a reasonable value for the string tension of cosmic strings implies $R^2 \sim 10^8 G$. Hence the value of G_{cl} is roughly $G_{cl} \sim 10^7 G$ in electromagnetic case and seven orders of magnitude stronger than the gravitational coupling associated with the graviton exchange.

The resolution of the puzzling result has been already described. R-N metric does not allow embedding as non-vacuum extremal and the effective metric for M^4 defining the GRT limit of TGD in long length scales need not be equal to the induced metric. One cannot however exclude the possibility that the effective metric co-incides with the induced metric for vacuum extremal: in this case the gravitational constant remains free parameter.

Although the result as such kills the idea about strong gravity associated with the classical gauge fields, the implications of the result that classical fields are related to gravitational field in a very simple manner could be non-trivial. If TGD indeed predicts correctly the gravitational coupling associated with the exchange of CP_2 type extremals, then classical gauge fields associated with the physical systems can give additional very strong contribution to the gravitational field generated by the body. If one assumes that the classical gauge fields have as their sources ordinary matter (purely vacuum charge densities are not excluded), highly charged objects are expected to exhibit gravitational anomalies. Not only electro-gravity but also Z^0 gravity are possible: any $U(1)$ gauge field can define vacuum gravity. There are two basic situations: non-vacuum situation in which Kähler form is the natural gauge field and identifiable as being associated with the $U(1)$ factor of electro-weak gauge group and vacuum situation in which gauge field in is $SU(2)_L$ algebra. In the latter case the extremization does not pose any limitations to the embedding but criticality is expected to select small deformations of some extremals.

Also the general solutions of the field equations representable as maps from M^4 to CP_2 give additional contribution to the gravitational interaction. In this case it is however not clear whether the Einstein tensor allows a solution of Einstein's equations for some simple system.

4.3 Gravito-Maxwell Field Associated With A Dipole Field

A little explicit calculation modelling the Maxwell field as a dipole field demonstrates that the gravitational field has quadrupole character and that the additional mass associated with the disk is positive. This involves two delicate facts. Dipole gauge potential $A_0 \propto \overline{p} \cdot \overline{r}/r^3$ vanishes at the equator. One has

$$A_0 = [cos(\Theta) + cos(\Theta_0)]\,\omega = \frac{1}{4\pi}\frac{\overline{p}\cdot\overline{r}}{r^3} \quad . \tag{4.6}$$

Gravito-Maxwell field is obtained from the dipole field by multiplying it with A_0-factor.

1. For $cos(\theta_0) = 0$ one obtains

$$\overline{E}_g = \frac{R^2}{2}A_0 \times \overline{E} = \frac{R^2}{2}\frac{p^2}{16\pi^2}cos(\theta) \times [\overline{e}_z - 3cos(\theta)\overline{e}_r]\,\frac{1}{r^5} \quad .$$

   Note that θ refers to the angle variable o M^4 spherical coordinates. Since A_0-factor vanishes at the equator and has opposite sign above and below equator, one obtains quadrupole type gravito-Maxwell field and it is easy to verify that it can be interpreted as attractive gravitational field generated by the super-conductor. Note that the sign of the gravito-Maxwell field does not depend on the sign of the dipole moment nor on the sign of the frequency ω. The field in question behaves as $1/r^5$ so that the gravitational anomaly is only felt in the region near to the non-rotating super-conductor.

2. For $cos(\theta_0) = \pm 1$ on opposite sides of the hemisphere one has

$$A_0 = cos(\Theta)\omega = \epsilon\omega + \frac{1}{4\pi}\frac{\overline{p}\cdot\overline{r}}{r^3} \ . \tag{4.7}$$

The requirement that the potential is imbeddable for $r > d$ ($\cos(\Theta) \leq 1$), where d characterizes the source region (super-conductor), implies

$$|\omega| \ \geq \ \omega_{min} = \frac{|p|}{4\pi d^2} \ . \tag{4.8}$$

In this case one has

$$\overline{E}_g \ = \ \frac{R^2}{2}\frac{p}{4\pi}\left[\epsilon\omega + \frac{pcos(\theta)}{4\pi r^2}\right] \times [\overline{e}_z - 3cos(\theta)\overline{e}_r]\,\frac{1}{r^3} \ . \tag{4.9}$$

For $r^2 >> p/(4\pi\omega)\ cos(\Theta)$ is effective constant and the behavior of the gravito-Maxwell field is in a good approximation

$$\overline{E}_g \simeq \frac{R^2}{2}\frac{p}{4\pi}\epsilon\omega \times [\overline{e}_z - 3cos(\theta)\overline{e}_r]\,\frac{1}{r^3} \ . \tag{4.10}$$

The gravito-Maxwell field decreases as $1/r^3$ asymptotically for all values of θ. What is remarkable that even in the nearby region not too near to north and south pole it is possible to have a situation in which the constant term is much larger than the dipole term in the potential. The field changes sign at the equator: this is consistent with the fact that gravitational field cannot be a dipole field and expresses the fact that equator effectively acts as a charged sheet carrying gravito-Maxwell charge density. It must be emphasized that the singular behavior is actually due to the monopole character of the gauge field in turn reflecting itself in the monopole character of Riemann connection and thus also of the gravito-Maxwell scalar potential.

Order of magnitude estimate using the acceleration in Earth's gravitational field as a comparison standard is in order.

1. Consider first di-electric. Let the size of the system be d and dipole strength $p = \alpha N d^3$, $N = \epsilon N_n xa$, N_n is the density of nuclei, ϵN_n the density of polarizable charge and xa the distance between polarized charges in nucleus expressed using atomic radius as a unit.

   This gives the order of magnitude estimate

$$\frac{E_g c^2}{g} \sim \frac{\alpha^2}{2}\epsilon^2 x^2 \frac{R^2 a^2 c^2}{gL^5} N_n^2 d^6 \ . \tag{4.11}$$

2. In the case of conducting sphere of radius r with dipole moment $p \sim Qd$, $\sigma \sim \epsilon N_n x a d^2$, with xa denoting the thickness of surface charge layer on obtains the following estimate:

$$\frac{E_g c^2}{g} \sim \frac{\alpha^2}{2}\epsilon^2 x^2 \frac{R^2 a^2 c^2}{gL^5} N_n^2 d^6 \ . \tag{4.12}$$

The orders of magnitude are same. For $L = 1$ m, $d = .1$ m, $a = 10^{-10}$ m, $N_n = \frac{10^{30}}{A}/\mathrm{m}^3$, A atomic number and using $g = 10$ m^2/s, $R \sim 10^{-30}$ m, one has $\frac{E_g c^2}{g} \sim 10^{-14}\epsilon^2 x^2/A^2$. Hence the effect on the gravitational field is very weak.

5 Allais Effect And TGD

5.1 Introduction

Allais effect [E1, E15] is a fascinating gravitational anomaly associated with solar eclipses. It was discovered originally by M. Allais, a Nobelist in the field of economy, and has been reproduced in several experiments but not as a rule. The experimental arrangement uses so called paraconical pendulum, which differs from the Foucault pendulum in that the oscillation plane of the pendulum can rotate in certain limits so that the motion occurs effectively at the surface of sphere.

5.1.1 Experimental findings

Consider first a brief summary of the findings of Allais and others [E15].

1. In the ideal situation (that is in the absence of any other forces than gravitation of Earth) paraconical pendulum should behave like a Foucault pendulum. The oscillation plane of the paraconical pendulum however begins to rotate.

2. 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.

3. 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, E11] which happens to correspond to the constant $v_0 = 2^{-11}$ appearing in the formula of the gravitational Planck constant. 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.

4. There is also quite recent finding by Popescu and Olenici, which they interpret as a quantization of the plane of oscillation of paraconical oscillator during solar eclipse [E16].

5.1.2 TGD based models for Allais effect

I have already earlier proposed an explanation of the effect in terms of classical Z^0 force. If the Z^0 charge to mass ratio of pendulum varies and if Earth and Moon are Z^0 conductors, the resulting model is quite flexible and one might hope it could explain the high variation of the experimental results.

The rapid variation of the effect during the eclipse is however a problem for this approach and suggests that gravitational screening or some more general interference effect might be present. Gravitational screening alone cannot however explain Allais effect. Also the combination of gravitational screening and Z^0 force assuming Z^0 conducting structures causing screening fails to explain the discontinuous behavior when massive objects are collinear.

A model based on the idea that gravitational interaction is mediated by topological light rays (MEs) and that gravitons correspond to a gigantic value of the gravitational Planck constant however explains the Allais effect as an interference effect made possible by macroscopic quantum coherence in astrophysical length scales. Equivalence Principle fixes the model to a high degree and one ends up with an explicit formula for the anomalous gravitational acceleration and the general order of magnitude and the large variation of the frequency change as being due to the variation of the distance ratio $r_{S,P}/r_{M,P}$ (S, M, and P refer to Sun, Moon, and pendulum respectively). One can say that the pendulum acts as an interferometer.

5.2 Could Gravitational Screening Explain Allais Effect

The basic idea of the screening model is that Moon absorbs some fraction of the gravitational momentum flow of Sun and in this manner partially screens the gravitational force of Sun in a disk like region having the size of Moon's cross subsection. The screening is expected to be strongest in the center of the disk. Screening model happens to explain the findings of Jevardan but fails in the general case. Despite this screening model serves as a useful exercise.

5.2.1 Constant external force as the cause of the effect

The conclusions of Allais motivate the assumption that quite generally there can be additional constant forces affecting the motion of the paraconical pendulum besides Earth's gravitation. This means the replacement $\overline{g} \rightarrow \overline{g}+\Delta\overline{g}$ of the acceleration g due to Earth's gravitation. $\Delta\overline{g}$ can depend on time.

The system obeys still the same simple equations of motion as in the initial situation, the only change being that the direction and magnitude of effective Earth's acceleration have changed so that the definition of vertical is modified. If $\Delta\overline{g}$ is not parallel to the oscillation plane in the original situation, a torque is induced and the oscillation plane begins to rotate. This picture requires that the friction in the rotational degree of freedom is considerably stronger than in oscillatory degree of freedom: unfortunately I do not know what the situation is.

The behavior of the system in absence of friction can be deduced from the conservation laws of energy and angular momentum in the direction of $\overline{g} + \Delta\overline{g}$. The explicit formulas are given by

$$\begin{aligned} E &= \frac{ml^2}{2}(\frac{d\Theta}{dt})^2 + sin^2(\Theta)(\frac{d\Phi}{dt})^2 + mglcos(\Theta) \ , \\ L_z &= ml^2 sin^2(\Theta)\frac{d\Phi}{dt} \ . \end{aligned} \tag{5.1}$$

and allow to integrate Θ and Φ from given initial values.

5.2.2 What causes the effect in normal situations?

The gravitational accelerations caused by Sun and Moon come first in mind as causes of the effect. Equivalence Principle implies that only relative accelerations causing analogs of tidal forces can be in question. In GRT picture these accelerations correspond to a geodesic deviation between the surface of Earth and its center. The general form of the tidal acceleration would thus the difference of gravitational accelerations at these points:

$$\Delta\overline{g} = -2GM[\frac{\Delta\overline{r}}{r^3} - 3\frac{\overline{r}\cdot\Delta\overline{r}\overline{r}}{r^5}] \ . \tag{5.2}$$

Here $\overline{r}$ denotes the relative position of the pendulum with respect to Sun or Moon. $\Delta\overline{r}$ denotes the position vector of the pendulum measured with respect to the center of Earth defining the geodesic deviation. The contribution in the direction of $\Delta\overline{r}$ does not affect the direction of the Earth's acceleration and therefore does not contribute to the torque. Second contribution corresponds to an acceleration in the direction of $\overline{r}$ connecting the pendulum to Moon or Sun. The direction of this vector changes slowly.

This would suggest that in the normal situation the tidal effect of Moon causes gradually changing force $m\Delta\overline{g}$ creating a torque, which induces a rotation of the oscillation plane. Together with dissipation this leads to a situation in which the orbital plane contains the vector $\Delta\overline{g}$ so that no torque is experienced. The limiting oscillation plane should rotate with same period as Moon around Earth. Of course, if effect is due to some other force than gravitational forces of Sun and Earth, paraconical oscillator would provide a way to make this force visible and quantify its effects.

5.2.3 What would happen during the solar eclipse?

During the solar eclipse something exceptional must happen in order to account for the size of effect. The finding of Allais that the limiting oscillation plane contains the line connecting Earth, Moon, and Sun implies that the anomalous acceleration $\Delta|g$ should be parallel to this line during the solar eclipse.

The simplest hypothesis is based on TGD based view about gravitational force as a flow of gravitational momentum in the radial direction.

1. For stationary states the field equations of TGD for vacuum extremals state that the gravitational momentum flow of this momentum. Newton's equations suggest that planets and moon absorb a fraction of gravitational momentum flow meeting them. The view that gravitation is mediated by gravitons which correspond to enormous values of gravitational Planck constant in turn supports Feynman diagrammatic view in which description as momentum exchange makes sense and is consistent with the idea about absorption. If Moon absorbs part of this momentum, the region of Earth screened by Moon receives reduced amount of gravitational momentum and the gravitational force of Sun on pendulum is reduced in the shadow.

2. Unless the Moon as a coherent whole acts as the absorber of gravitational four momentum, one expects that the screening depends on the distance travelled by the gravitational flux inside Moon. Hence the effect should be strongest in the center of the shadow and weaken as one approaches its boundaries.

3. The opening angle for the shadow cone is given in a good approximation by $\Delta\Theta = R_M/R_E$. Since the distances of Moon and Earth from Sun differ so little, the size of the screened region has same size as Moon. This corresponds roughly to a disk with radius $.27 \times R_E$.

   The corresponding area is 7.3 per cent of total transverse area of Earth. If total absorption occurs in the entire area the total radial gravitational momentum received by Earth is in good approximation 92.7 per cent of normal during the eclipse and the natural question is whether this effective repulsive radial force increases the orbital radius of Earth during the eclipse.

   More precisely, the deviation of the total amount of gravitational momentum absorbed during solar eclipse from its standard value is an integral of the flux of momentum over time:

$$\begin{aligned} \Delta P^k_{gr} &= \int \frac{\Delta P^k_{gr}}{dt}(S(t))dt \ , \\ \frac{\Delta P^k_{gr}}{dt}(S(t)) &= \int_{S(t)} J^k_{gr}(t)dS \ . \end{aligned} \tag{5.3}$$

   This prediction could kill the model in classical form at least. If one takes seriously the quantum model for astrophysical systems predicting that planetary orbits correspond to Bohr orbits with gravitational Planck constant equal to $\hbar_{gr} = GMm/v_0$, $v_0 = 2^{-11}$, there should be not effect on the orbital radius. The anomalous radial gravitational four-momentum could go to some other degrees of freedom at the surface of Earth.

4. The rotation of the oscillation plane is largest if the plane of oscillation in the initial situation is as orthogonal as possible to the line connecting Moon, Earth and Sun. The effect vanishes when this line is in the initial plane of oscillation. This testable prediction might explain why some experiments have failed to reproduce the effect.

5. The change of $|\overline{g}|$ to $|\overline{g}+\Delta\overline{g}|$ induces a change of oscillation frequency given by

$$\frac{\Delta f}{f} = \frac{\overline{g}\cdot\Delta\overline{g}}{g^2} = \frac{\Delta g}{g}cos(\theta) \ . \tag{5.4}$$

   If the gravitational force of the Sun is screened, one has $|\overline{g}+\Delta\overline{g}| > g$ and the oscillation frequency should increase. The upper bound for the effect corresponds to vertical direction is obtained from the gravitational acceleration of Sun at the surface of Earth:

$$\frac{|\Delta f|}{f} \leq \frac{\Delta g}{g} = \frac{v_E^2}{r_E} \simeq 6.0 \times 10^{-4} \ . \tag{5.5}$$

6. One should explain also the recent finding by Popescu and Olenici, which they interpret as a quantization of the plane of oscillation of paraconical oscillator during solar eclipse [E16]. A possible TGD based explanation would be in terms of quantization of $\Delta\overline{g}$ and thus of the limiting oscillation plane. This quantization should reflect the quantization of the gravitational momentum flux receiving Earth. The flux would be reduced in a stepwise manner during the solar eclipse as the distance traversed by the flux through Moon increases and reduced in a similar manner after the maximum of the eclipse.

5.2.4 What kind of tidal effects are predicted?

If the model applies also in the case of Earth itself, new kind of tidal effects are predicted due to the screening of the gravitational effects of Sun and Moon inside Earth. At the night-side the paraconical pendulum should experience the gravitation of Sun as screened. Same would apply to the "night-side" of Earth with respect to Moon.

Consider first the differences of accelerations in the direction of the line connecting Earth to Sun/Moon: these effects are not essential for tidal effects. The estimate for the ratio for the orders of magnitudes of the these accelerations is given by

$$\frac{|\Delta\overline{g}_{\perp}(Moon)|}{|\Delta\overline{g}_{\perp}(Sun)|} = \frac{M_S}{M_M}(\frac{r_M}{r_E})^3 \simeq 2.17 \ . \tag{5.6}$$

The order or magnitude follows from $r(Moon) = .0026$ AU and $M_M/M_S = 3.7 \times 10^{-8}$. These effects are of same order of magnitude and can be compensated by a variation of the pressure gradients of atmosphere and sea water. The effects caused by Sun are two times stronger. These effects are of same order of magnitude and can be compensated by a variation of the pressure gradients of atmosphere and sea water.

The tangential accelerations are essential for tidal effects. They decompose as

$$\frac{1}{r^3}\left[\Delta\overline{r} - 3|\Delta\overline{r}|cos(\Theta)\frac{\overline{r}}{r}\right] \ .$$

$\pi/4 \leq \Theta \leq \pi/2$ is the angle between $\Delta\overline{r}$ and $\overline{r}$. The above estimate for the ratio of the contributions of Sun and Moon holds true also now and the tidal effects caused by Sun are stronger by a factor of two.

Consider now the new tidal effects caused by the screening.

1. Tangential effects on day-side of Earth are not affected (night-time and night-side are of course different notions in the case of Moon and Sun). At the night-side screening is predicted to reduce tidal effects with a maximum reduction at the equator.

2. Second class of new effects relate to the change of the normal component of the forces and these effects would be compensated by pressure changes corresponding to the change of the effective gravitational acceleration. The night-day variation of the atmospheric and sea pressures would be considerably larger than in Newtonian model.

The intuitive expectation is that the screening is maximum when the gravitational momentum flux travels longest path in the Earth's interior. The maximal difference of radial accelerations associated with opposite sides of Earth along the line of sight to Moon/Sun provides a convenient manner to distinguish between Newtonian and TGD based models:

$$\begin{aligned} |\Delta\overline{g}_{\perp,N}| &= 4GM \times \frac{R_E}{r^3} \ , \\ |\Delta\overline{g}_{\perp,TGD}| &= 4GM \times \frac{1}{r^2} \ . \end{aligned} \tag{5.7}$$

The ratio of the effects predicted by TGD and Newtonian models would be

M_M/M_S	M_E/M_S	R_M/R_E	d_{E-S}/AU	d_{E-M}/AU
3.0×10^{-6}	3.69×10^{-8}	.273	1	.00257
R_E/d_{E-S}	R_E/d_{E-M}	g_S/g	g_M/g	
4.27×10^{-5}	01.7×10^{-7}	6.1×10^{-4}	2.8×10^{-4}	

Table 1: Table gives basic data relevant for tidal effects. The subscript E, S, M refers to Earth, Sun, Moon; R refers to radius; d_{X-Y} refers to the distance between X and Y g_S and g_M refer to accelerations induced by Sun and Moon at Earth surface. $g = 9.8$ m/s^2 refers to the acceleration of gravity at surface of Earth. One has also $M_S = 1.99\times 10^{30}$ kg and $AU = 1.49\times 10^{11}$ m, $R_E = 6.34\times 10^6$ m.

$$\begin{aligned} \frac{|\Delta\overline{g}_{\perp,TGD}|}{|\Delta\overline{g}_{\perp,N}|} &= \frac{r}{R_E} \ , \\ \frac{r_M}{R_E} &= 60.2 \ , \ \frac{r_S}{R_E} = 2.34\times 10^4 \ . \end{aligned} \tag{5.8}$$

The amplitude for the oscillatory variation of the pressure gradient caused by Sun would be

$$\Delta|\nabla p_S| = \frac{v_E^2}{r_E} \simeq 6.1\times 10^{-4} g$$

and the pressure gradient would be reduced during night-time. The corresponding amplitude in the case of Moon is given by

$$\frac{\Delta|\nabla p_s|}{\Delta|\nabla p_M|} = \frac{M_S}{M_M}\times (\frac{r_M}{r_S})^3 \simeq 2.17 \ .$$

$\Delta|\nabla p_M$ is in a good approximation smaller by a factor of 1/2 and given by $\Delta|\nabla p_M| = 2.8\times 10^{-4} g$. Thus the contributions are of same order of magnitude.

One can imagine two simple qualitative killer predictions assuming maximal gravitational screening.

1. Solar eclipse should induce anomalous tidal effects induced by the screening in the shadow of the Moon.

2. The comparison of solar and moon eclipses might kill the scenario. The screening would imply that inside the shadow the tidal effects are of same order of magnitude at both sides of Earth for Sun-Earth-Moon configuration but weaker at night-side for Sun-Moon-Earth situation.

5.2.5 An interesting co-incidence

The value of $\Delta f/f = 5\times 10^{-4}$ in experiment of Jeverdan is exactly equal to $v_0 = 2^{-11}$, which appears in the formula $\hbar_{gr} = GMm/v_0$ for the favored values of the gravitational Planck constant. The predictions are $\Delta f/f \leq \Delta p/p \simeq 3\times 10^{-4}$. Powers of $1/v_0$ appear also as favored scalings of Planck constant in the TGD inspired quantum model of bio-systems based on dark matter [K3]. This co-incidence would suggest the quantization formula

$$\frac{g_E}{g_S} = \frac{M_S}{M_E}\times \frac{R_E^2}{r_E^2} = v_0 \tag{5.9}$$

for the ratio of the gravitational accelerations caused by Earth and Sun on an object at the surface of Earth.

It must be however admitted that the larger variation in the magnitude and even sign of the effect does not favor this kind of interpretation.

5.2.6 Summary of the predicted new effects

Let us sum up the basic predictions of the model assuming maximal gravitational screening.

1. The first prediction is the gradual increase of the oscillation frequency of the conical pendulum by $\Delta f/f \leq 3\times 10^{-4}$ to maximum and back during night-time in case that the pendulum has vanishing Z^0 charge. Also a periodic variation of the frequency and a periodic rotation of the oscillation plane with period co-inciding with Moon's rotation period is predicted. Already Allais observed both 24 hour cycle and cycle which is slightly longer and due to the fact that Moon rates around Earth.

2. A paraconical pendulum with initial position, which corresponds to the resting position in the normal situation should begin to oscillate during solar eclipse. This effect is testable by fixing the pendulum to the resting position and releasing it during the eclipse. The amplitude of the oscillation corresponds to the angle between $\overline{g}$ and $\overline{g}+\Delta\overline{g}$ given in a good approximation by

$$sin[\Theta(\overline{g},\overline{g}+\Delta\overline{g})] \quad = \quad \frac{\Delta g}{g} sin[\Theta(\overline{g},\Delta\overline{g})] \quad . \tag{5.10}$$

   An upper bound for the amplitude would be $\Theta \leq 3\times 10^{-4}$, which corresponds to.015 degrees. Z^0 charge of the pendulum would modify this simple picture.

3. Gravitational screening should cause a reduction of tidal effects at the "night-side" of Moon/Sun. The reduction should be maximum at "midnight". This reduction together with the fact that the tidal effects of Moon and Sun at the day side are of same order of magnitude could explain some anomalies know to be associated with the tidal effects [F1]. A further prediction is the day-night variation of the atmospheric and sea pressure gradients with amplitude which is for Sun $3\times 10^{-4}g$ and for Moon $1.3\times 10^{-3}g$.

To sum up, the predicted anomalous tidal effects and the explanation of the limiting oscillation plane in terms of stronger dissipation in rotational degree of freedom could kill the model assuming only gravitational screening.

5.2.7 Comparison with experimental results

The experimental results look mutually contradictory in the context provided by the model assuming only screening. Some experiments find no anomaly at all as one learns from [E1]. There are also measurements supporting the existence of an effect but with varying sign and quite different orders of magnitude. Either the experimental determinations cannot be trusted or the model is too simple.

1. The *increase* (!) of the frequency observed by Jeverdan and collaborators reported in Wikipedia article [E1] for Foucault pendulum is $\Delta f/f \simeq 5\times 10^{-4}$ would support the model even quantitatively since this value is only by a factor 5/3 higher than the maximal effect allowed by the screening model. Unfortunately, I do not have an access to the paper of Jeverdan *et al* to find out the value of $cos(\Theta)$ in the experimental arrangement and whether there is indeed a decrease of the period as claimed in Wikipedia article. In [E7] two experiments supporting an effect $\Delta g/g = x\times 10^{-4}$, $x = 1.5$ or 2.6 but the sign of the effect is different in these experiments.

2. Allais reported an anomaly $\Delta g/g \sim 5\times 10^{-6}$ during 1954 eclipse [E4]. According to measurements by authors of [E7] the period of oscillation increases and one has $\Delta g/g \sim 5\times 10^{-6}$. Popescu and Olenici report a decrease of the oscillation period by $(\Delta g/g)cos(\Theta) \simeq 1.4\times 10^{-5}$.

3. In [E9] a *reduction* of vertical gravitational acceleration $\Delta g/g = (7.0\pm 2.7)\times 10^{-9}$ is reported: this is by a factor 10^{-5} smaller than the result of Jeverdan.

4. Small pressure waves with $\Delta p/p = 2 \times 10^{-5}$ are registered by some micro-barometers [E4] and might relate to the effect since pressure gradient and gravitational acceleration should compensate each other. $\Delta g cos(\Theta)/g$ would be about 7 per cent of its maximum value for Earth-Sun system in this case. The knowledge of the sign of pressure variation would tell whether effective gravitational force is screened or amplified by Moon.

5.3 Allais Effect As Evidence For Large Values Of Gravitational Planck Constant?

One can represent rather general counter arguments against the models based on Z^0 conductivity and gravitational screening if one takes seriously the puzzling experimental findings concerning frequency change.

1. Allais effect identified as a rotation of oscillation plane seems to be established and seems to be present always and can be understood in terms of torque implying limiting oscillation plane.

2. During solar eclipses Allais effect however becomes much stronger. According to Olenici's experimental work the effect appears always when massive objects form collinear structures.

3. The behavior of the change of oscillation frequency seems puzzling. The sign of the frequency increment varies from experiment to experiment and its magnitude varies within five orders of magnitude.

5.3.1 What one an conclude about general pattern for $\Delta f/f$?

The above findings allow to make some important conclusions about the nature of Allais effect.

1. Some genuinely new dynamical effect should take place when the objects are collinear. If gravitational screening would cause the effect the frequency would always grow but this is not the case.

2. If stellar objects and also ring like dark matter structures possibly assignable to their orbits are Z^0 conductors, one obtains screening effect by polarization and for the ring like structure the resulting effectively 2-D dipole field behaves as $1/\rho^2$ so that there are hopes of obtaining large screening effects and if the Z^0 charge of pendulum is allow to have both signs, one might hope of being to able to explain the effect. It is however difficult to understand why this effect should become so strong in the collinear case.

3. The apparent randomness of the frequency change suggests that interference effect made possible by the gigantic value of gravitational Planck constant is in question. On the other hand, the dependence of $\Delta g/g$ on pendulum suggests a breaking of Equivalence Principle. It however turns out that the variation of the distances of the pendulum to Sun and Moon can explain the experimental findings since the pendulum turns out to act as a sensitive gravitational interferometer. An apparent breaking of Equivalence Principle could result if the effect is partially caused by genuine gauge forces, say dark classical Z^0 force, which can have arbitrarily long range in TGD Universe.

4. If topological light rays (MEs) provide a microscopic description for gravitation and other gauge interactions one can envision these interactions in terms of MEs extending from Sun/Moon radially to pendulum system. What comes in mind that in a collinear configuration the signals along S-P MEs and M-P MEs superpose linearly so that amplitudes are summed and interference terms give rise to an anomalous effect with a very sensitive dependence on the difference of S-P and M-P distances and possible other parameters of the problem. One can imagine several detailed variants of the mechanism. It is possible that signal from Sun combines with a signal from Earth and propagates along Moon-Earth ME or that the interferences of these signals occurs at Earth and pendulum.

5. Interference suggests macroscopic quantum effect in astrophysical length scales and thus gravitational Planck constants given by $\hbar_{gr} = GMm/v_0$, where $v_0 = 2^{-11}$ is the favored value, should appear in the model. Since $\hbar_{gr} = GMm/v_0$ depends on both masses this could give also a sensitive dependence on mass of the pendulum. One expects that the anomalous force is proportional to $\hbar_{gr}$ and is therefore gigantic as compared to the effect predicted for the ordinary value of Planck constant.

5.3.2 Model for interaction via gravitational MEs with large Planck constant

Restricting the consideration for simplicity only gravitational MEs, a concrete model for the situation would be as follows.

1. The picture based on topological light rays suggests that the gravitational force between two objects M and m has the following expression

$$\begin{aligned} F_{M,m} &= \frac{GMm}{r^2} = \int |S(\lambda, r)|^2 p(\lambda) d\lambda \\ p(\lambda) &= \frac{\hbar_{gr}(M,m) 2\pi}{\lambda} \ , \ \hbar_{gr} = \frac{GMm}{v_0(M,m)} \ . \end{aligned} \tag{5.11}$$

   $p(\lambda)$ denotes the momentum of the gravitational wave propagating along ME. v_0 can depend on (M,m) pair. The interpretation is that $|S(\lambda,r)|^2$ gives the rate for the emission of gravitational waves propagating along ME connecting the masses, having wave length λ, and being absorbed by m at distance r.

2. Assume that $S(\lambda, r)$ has the decomposition

$$\begin{aligned} S(\lambda, r) &= R(\lambda) exp\left[i\Phi(\lambda)\right] \frac{exp\left[ik(\lambda)r\right]}{r} \ , \\ exp\left[ik(\lambda)r\right] &= exp\left[ip(\lambda)r/\hbar_{gr}(M,m)\right] \ , \\ R(\lambda) &= |S(\lambda,r)| \ . \end{aligned} \tag{5.12}$$

   The phases $exp(i\Phi(\lambda))$ might be interpreted in terms of scattering matrix. The simplest assumption is $\Phi(\lambda) = 0$ turns out to be consistent with the experimental findings. The substitution of this expression to the above formula gives the condition

$$\int |R(\lambda)|^2 \frac{d\lambda}{\lambda} = v_0 \ . \tag{5.13}$$

Consider now a model for the Allais effect based on this picture.

1. In the non-collinear case one obtains just the standard Newtonian prediction for the net forces caused by Sun and Moon on the pendulum since $Z_{S,P}$ and $Z_{M,P}$ correspond to non-parallel MEs and there is no interference.

2. In the collinear case the interference takes place. If interference occurs for identical momenta, the interfering wavelengths are related by the condition

$$p(\lambda_{S,P}) = p(\lambda_{M,P} \ . \tag{5.14}$$

   This gives

$$\frac{\lambda_{M,P}}{\lambda_{S,P}} = \frac{\hbar_{M,P}}{\hbar_{S,P}} = \frac{M_M}{M_S}\frac{v_0(S,P)}{v_0(M,P)} \ . \tag{5.15}$$

3. The net gravitational force is given by

$$
\begin{aligned}
F_{gr} &= \int |Z(\lambda, r_{S,P}) + Z(\lambda/x, r_{M,P})|^2 p(\lambda) d\lambda \\
&= F_{gr}(S,P) + F_{gr}(M,P) + \Delta F_{gr} \ , \\
\Delta F_{gr} &= 2\int Re\left[S(\lambda, r_{S,P})\overline{S}(\lambda/x, r_{M,P}))\right] \frac{\hbar_{gr}(S,P)2\pi}{\lambda} d\lambda \ , \\
x &= \frac{\hbar_{S,P}}{\hbar_{M,P}} = \frac{M_S}{M_M}\frac{v_0(M,P)}{v_0(S,P)} \ .
\end{aligned}
\quad (5.16)
$$

Here $r_{M,P}$ is the distance between Moon and pendulum. The anomalous term ΔF_{gr} would be responsible for the Allais effect and change of the frequency of the oscillator.

4. The anomalous gravitational acceleration can be written explicitly as

$$
\begin{aligned}
\Delta a_{gr} &= 2\frac{GM_S}{r_S r_M}\frac{1}{v_0(S,P)} \times I \ , \\
I &= \int R(\lambda)R(\lambda/x) cos\left[\Phi(\lambda) - \Phi(\lambda/x) + 2\pi\frac{(y_S r_S - x y_M r_M)}{lambda}\right]\frac{d\lambda}{\lambda} \ , \\
y_M &= \frac{r_{M,P}}{r_M} \ , \ y_S = \frac{r_{S,P}}{r_S} \ .
\end{aligned}
\quad (5.17)
$$

Here the parameter y_M (y_S) is used express the distance $r_{M,P}$ ($r_{S,P}$) between pendulum and Moon (Sun) in terms of the semi-major axis r_M (r_S)) of Moon's (Earth's) orbit. The interference term is sensitive to the ratio $2\pi(y_S r_S - x y_M r_M)/\lambda$. For short wave lengths the integral is expected to not give a considerable contribution so that the main contribution should come from long wave lengths. The gigantic value of gravitational Planck constant and its dependence on the masses implies that the anomalous force has correct form and can also be large enough.

5. If one poses no boundary conditions on MEs the full continuum of wavelengths is allowed. For very long wave lengths the sign of the cosine terms oscillates so that the value of the integral is very sensitive to the values of various parameters appearing in it. This could explain random looking outcome of experiments measuring $\Delta f/f$. One can also consider the possibility that MEs satisfy periodic boundary conditions so that only wave lengths $\lambda_n = 2r_S/n$ are allowed: this implies $sin(2\pi y_S r_S/\lambda) = 0$. Assuming this, one can write the magnitude of the anomalous gravitational acceleration as

$$
\begin{aligned}
\Delta a_{gr} &= 2\frac{GM_S}{r_{S,P} r_{M,P}} \times \frac{1}{v_0(S,P)} \times I \ , \\
I &= \sum_{n=1}^{\infty} R(\frac{2r_{S,P}}{n})R(\frac{2r_{S,P}}{nx})(-1)^n cos\left[\Phi(n) - \Phi(xn) + n\pi\frac{x y_M}{y_S}\frac{r_M}{r_S}\right] \ .
\end{aligned}
\quad (5.18)
$$

If $R(\lambda)$ decreases as λ^k, $k > 0$, at short wavelengths, the dominating contribution corresponds to the lowest harmonics. In all terms except cosine terms one can approximate $r_{S,P}$ *resp.* $r_{M,P}$ with r_S *resp.* r_M.

6. The presence of the alternating sum gives hopes for explaining the strong dependence of the anomaly term on the experimental arrangement. The reason is that the value of xyr_M/r_S appearing in the argument of cosine is rather large:

$$
\frac{x y_M}{y_S}\frac{r_M}{r_S} = \frac{y_M}{y_S}\frac{M_S}{M_M}\frac{r_M}{r_S}\frac{v_0(M,P)}{v_0(S,P)} \simeq 6.95671837 \times 10^4 \times \frac{y_M}{y_S} \times \frac{v_0(M,P)}{v_0(S,P)} \ .
$$

The values of cosine terms are very sensitive to the exact value of the factor $M_S r_M/M_M r_S$ and the above expression is probably not quite accurate value. As a consequence, the values and signs of the cosine terms are very sensitive to the values of y_M/y_S and $\frac{v_0(M,P)}{v_0(S,P)}$.

The value of y_M/y_S varies from experiment to experiment and this alone could explain the high variability of $\Delta f/f$. The experimental arrangement would act like interferometer measuring the distance ratio $r_{M,P}/r_{S,P}$. Hence it seems that the condition

$$\frac{v_0(S,P)}{v_0(M,P)} \neq const. \tag{5.19}$$

implying breaking of Equivalence Principle is not necessary to explain the variation of the sign of $\Delta f/f$ and one can assume $v_0(S,P) = v_0(M,P) \equiv v_0$. One can also assume $\Phi(n) = 0$.

5.3.3 Scaling law

The assumption of the scaling law

$$R(\lambda) = R_0(\frac{\lambda}{\lambda_0})^k \tag{5.20}$$

is very natural in light of conformal invariance and masslessness of gravitons and allows to make the model more explicit. With the choice $\lambda_0 = r_S$ the anomaly term can be expressed in the form

$$\begin{aligned} \Delta a_{gr} &\simeq \frac{GM_S}{r_S r_M}\frac{2^{2k+1}}{v_0}(\frac{M_M}{M_S})^k R_0(S,P)R_0(M,P) \times \sum_{n=1}^{\infty}\frac{(-1)^n}{n^{2k}} cos\left[\Phi(n) - \Phi(xn) + n\pi K\right] , \\ K &= x \times \frac{r_M}{r_S} \times \frac{y_M}{y_S} . \end{aligned} \tag{5.21}$$

The normalization condition of Eq. 5.13 reads in this case as

$$R_0^2 = v_0 \times \frac{1}{2\pi \sum_n (\frac{1}{n})^{2k+1}} = \frac{v_0}{\pi\zeta(2k+1)} . \tag{5.22}$$

Note the shorthand $v_0(S/M,P) = v_0$. The anomalous gravitational acceleration is given by

$$\begin{aligned} \Delta a_{gr} &= \sqrt{\frac{v_0(M,P)}{v_0(S,P)}}\frac{GM_S}{r_S^2} \times XY \times \sum_{n=1}^{\infty}\frac{(-1)^n}{n^{2k}} cos\left[\Phi(n) - \Phi(xn) + n\pi K\right] , \\ X &= 2^{2k} \times \frac{r_S}{r_M} \times (\frac{M_M}{M_S})^k , \\ Y &= \frac{1}{\pi \sum_n (\frac{1}{n})^{2k+1}} = \frac{1}{\pi\zeta(2k+1)} . \end{aligned} \tag{5.23}$$

It is clear that a reasonable order of magnitude for the effect can be obtained if k is small enough and that this is essentially due to the gigantic value of gravitational Planck constant.

The simplest model consistent with experimental findings assumes $v_0(M,P) = v_0(S,P)$ and $\Phi(n) = 0$ and gives

k	1	1/2	1/4
$\frac{\Delta g}{gcos(\Theta)}$	1.1×10^{-9}	4.3×10^{-6}	1.97×10^{-4}

Table 2: Table gives overall magnitudes of the effect for $k = 1, 2/2$ and $1/4$ as predicted by the model.

$$\begin{aligned} \frac{\Delta a_{gr}}{gcos(\Theta)} &= \frac{GM_S}{r_S^2 g} \times XY \times \sum_{n=1}^{\infty} \frac{(-1)^n}{n^{2k}} cos(n\pi K) \ , \\ X &= 2^{2k} \times \frac{r_S}{r_M} \times (\frac{M_M}{M_S})^k \ , \\ Y &= \frac{1}{\pi \sum_n (\frac{1}{n})^{2k+1}} = \frac{1}{\pi\zeta(2k+1)} \ , \\ K &= x \times \frac{r_M}{r_S} \times \frac{y_M}{y_S} \ , \ x = \frac{M_S}{M_M} \ . \end{aligned} \quad (5.24)$$

5.3.4 Numerical estimates

To get a numerical grasp to the situation one can use $M_S/M_M \simeq 2.71 \times 10^7$, $r_S/r_M \simeq 389.1$, and $(M_S r_M/M_M r_S) \simeq 1.74 \times 10^4$. The overall order of magnitude of the effect would be

$$\begin{aligned} \frac{\Delta g}{g} &\sim XY \times \frac{GM_S}{R_S^2 g} cos(\Theta) \ , \\ \frac{GM_S}{R_S^2 g} &\simeq 6 \times 10^{-4} \ . \end{aligned} \quad (5.25)$$

The overall magnitude of the effect is determined by the factor XY.

1. For $k = 0$ the normalization factor is proportional to $1/\zeta(1)$ and diverges and it seems that this option cannot work.

2. Table 2 gives the predicted overall magnitudes of the effect for $k = 1, 2/2$ and $1/4$.

   For $k = 1$ the effect is too small to explain even the findings of [E9] since there is also a kinematic reduction factor coming from $cos(\Theta)$. Therefore $k < 1$ suggesting fractal behavior is required. For $k = 1/2$ the effect is of same order of magnitude as observed by Allais. The alternating sum equals in a good approximation to -.693 for $y_S/y_M = 1$ so that it is not possible to explain the finding $\Delta f/f \simeq 5 \times 10^{-4}$ of Jeverdan.

3. For $k = 1/4$ the expression for Δa_{gr} reads as

$$\begin{aligned} \frac{\Delta a_{gr}}{gcos(\Theta)} &\simeq 1.97 \times 10^{-4} \sum_{n=1}^{\infty} \frac{(-1)^n}{n^{1/2}} cos(n\pi K) \ , \\ K &= \frac{y_M}{y_S} u \ , \ u = \frac{M_S}{M_M} \frac{r_M}{r_S} \simeq 6.95671837 \times 10^4 \ . \end{aligned} \quad (5.26)$$

   The sensitivity of cosine terms to the precise value of y_M/y_S gives good hopes of explaining the strong variation of $\Delta f/f$ and also the findings of Jeverdan. Numerical experimentation indeed shows that the sign of the cosine sum alternates and its value increases as y_M/y_S increases in the range $[1, 2]$.

   The eccentricities of the orbits of Moon *resp.* Earth are $e_M = .0549$ *resp.* $e_E = .017$. Denoting semimajor and semiminor axes by a and b one has $\Delta = (a - b)/a = 1 - \sqrt{1 - e^2}$. $\Delta_M = 15 \times 10^{-4}$ *resp.* $\Delta_E = 1.4 \times 10^{-4}$ characterizes the variation of y_M *resp.* y_M due to the non-circularity of the orbits of Moon *resp.* Earth. The ratio $R_E/r_M = .0166$ characterizes the range of the variation $\Delta y_M = \Delta r_{M,P}/r_M \leq R_E/r_M$ due to the variation of the position of the laboratory. All these numbers are large enough to imply large variation of the argument of cosine term even for $n = 1$ and the variation due to the position at the surface of Earth is especially large.

The duration of full eclipse is of order 8 minutes which corresponds to angle $\phi = \pi/90$ and at equator roughly to a $\Delta y_N = (\sqrt{r_M^2 + R_E^2 sin^2(\pi/90)} - r_M)/r_M \simeq (\pi/90)^2 R_E^2/2r_M^2 \simeq 1.7 \times 10^{-7}$. Thus the change of argument of $n = 1$ cosine term during full eclipse is of order $\Delta\Phi = .012\pi$ at equator. The duration of the eclipse itself is of order two 2 hours giving $\Delta y_M \simeq 3.4 \times 10^{-5}$ and the change $\Delta\Phi = 2.4\pi$ of the argument of $n = 1$ cosine term.

5.4 Could Z^0 Force Be Present?

One can understand the experimental results without a breaking of Equivalence Principle if the pendulum acts as a quantum gravitational interferometer. One cannot exclude the possibility that there is also a dependence on pendulum. In this case one would have a breaking of Equivalence Principle, which could be tested using several penduli in the same experimental arrangement. The presence of Z^0 force could induce an apparent breaking of Equivalence Principle. The most plausible option is Z^0 MEs with large Planck constant. One can consider also an alternative purely classical option, which does not involve large values of Planck constant.

5.4.1 Could purely classical Z^0 force allow to understand the variation of $\Delta f/f$?

In the earlier model of the Allais effect (see Appendix) I proposed that the classical Z^0 force could be responsible for the effect. TGD indeed predicts that any object with gravitational mass must have non-vanishing em and Z^0 charges but leaves their magnitude and sign open.

1. If both Sun, Earth, and pendulum have Z^0 charges, one might even hope of understanding why the sign of the outcome of the experiment varies since he ratio of Z^0 charge to gravitational mass and even the sign of Z^0 charge of the pendulum might vary. Constant charge-to-mass ratio is of course the simplest hypothesis so that only an effective scaling of gravitational constant would be in question. A possible test is to use several penduli in the same experiment and find whether they give rise to same effect or not.

2. If Moon and Earth are Z^0 conductors, a Z^0 surface charge cancelling the tangential component of Z^0 force at the surface of Earth is generated and affects the vertical component of the force experienced by the pendulum. The vertical component of Z^0 force is $2F_Z cos(\theta)$ and thus proportional to $cos(\Theta)$ as also the effective screening force below the shadow of Moon during solar eclipse. When Sun is in a vertical direction, the induced dipole contribution doubles the radial Z^0 force near surface and the effect due to the gravitational screening would be maximal. For Sun in horizon there would be no Z^0 force and gravitational tidal effect of Sun would vanish in the first order so that over all anomalous effect would be smallest possible: for a full screening $\Delta f/f \simeq \Delta g^2/4g^2 \simeq 4.5 \times 10^{-8}$ would be predicted. One might hope that the opposite sign of gravitational and Z^0 contributions could be enough to explain the varying sign of the overall effect.

3. It seems necessary to have a screening effect associated with gravitational force in order to understand the rapid variation of the effect during the eclipse. The fact that the maximum effect corresponds to a maximum gravitational screening suggests that it is present and determines the general scale of variation for the effect. If the maximal Z^0 charge of the pendulum is such that Z^0 force is of the same order of magnitude as the maximal screening of the gravitational force and of opposite sign (that is attractive), one could perhaps understand the varying sign of the effect but the effect would develop continuously and begin before the main eclipse. If the sign of Z^0 charge of pendulum can vary, there is no difficulty in explaining the varying sign of the effect. An interesting possibility is that Moon, Sun and Earth have dark matter halos so that also gravitational screening could begin before the eclipse. The real test for the effect would come from tidal effects unless one can guarantee that the pendulum is Z^0 neutral or its Z^0 charge/mass ratio is always the same.

4. As noticed also by Allais, Newtonian theory does not give a satisfactory account of the tidal forces and there is possibility that tides give a quantitative grasp on situation. If Earth is Z^0 conductor tidal effects should be determined mainly by the gravitational force and modified by its screening whereas Z^0 force would contribute mainly to the pressure waves accompanying the shadows of Moon and Sun. The sign and magnitude of pressure waves below Sun and Moon could give a quantitative grasp of Z^0 forces of Sun and Moon. Z^0 surface charge would have opposite signs at the opposite sides of Earth along the line connecting Earth to Moon *resp.* Sun and depending on sign of Z^0 force the screening and Z^0 force would tend to amplify or cancel the net anomalous effect on pressure.

5. A strong counter argument against the model based on Z^0 force is that collinear configurations are reached in continuous manner from non-collinear ones in the case of Z^0 force and the fact that gravitational screening does not conform with the varying sign of the discontinuous effect occurring during the eclipse. It would seem that the effect in question is more general than screening and perhaps more like quantum mechanical interference effect in astrophysical length scale.

5.4.2 Could Z^0 MEs with large Planck constant be present?

The previous line of arguments for gravitational MEs generalizes in a straightforward manner to the case of Z^0 force. Generalizing the expression for the gravitational Planck constant one has $\hbar_{Z^0} = g_Z^2 Q_Z(M) Q_Z(m)/v_0$. Assuming proportionality of Z^0 charge to gravitational mass one obtains formally similar expression for the Z^0 force as in previous case. If Q_Z/M ratio is constant, Equivalence Principle holds true for the effective gravitational interaction if the sign of Z^0 charge is fixed. The breaking of Equivalence Principle would come naturally from the non-constancy of the $v_0(S,P)/v_0(M,P)$ ratio also in the recent case. The variation of the sign of $\Delta f/f$ would be explained in a trivial manner by the variation of the sign of Z^0 charge of pendulum but this explanation is not favored by Occam's razor.

6 Dark Z^0 Force In Astrophysical Length Scales

The findings of Shnoll give support for the predicted importance of dark Z^0 force in astrophysical length scales.

6.1 The Regularities In Radio Active Decay Rates Linked To Astrophysical Cycles

Russian scientists have discovered regularities in the rates of radio active, chemical and biochemical processes linked to astrophysical periodicities. The observations of Shnoll and his collaborators summarizing work of forty years, were published for a couple years ago in a respected Russian science journal [E8], [E8], but have been greeted with silence in media. It took two years before I learned from the discovery (I am grateful for Prof. Adrian Klein for informing me about the work). This silence strengthens further my impression that theoretical physicists have concluded that superstrings provide the final truth about everything above and below Planck length scale, and have therefore decided to turn their back to the empirical science. Also the fact that the discovery of Shnoll and his collaborators is in strong a conflict with the basic dogma of reductionism which is a basic tenet of standard physics including superstring models, might explain the peculiar silence. Certainly, at the times of Einstein empirical discovery of this caliber would have been a major scientific event.

6.1.1 Dark Z^0 force as explanation of the observations

The observations of Shnoll and collaborators can be summarized by two statements.

1. The rate distributions for radio active decays and chemical and biochemical processes do not converge to single bell curve as suggested by quantum randomness plus standard model but to distributions which have several pronounced peaks.

2. The shapes of the rate curves seem to be similar to widely different reactions (radio-active decays, chemical and biochemical processes) but they fluctuate with time and fluctuation periods correspond to various astrophysical periods: day, month, year, ...

The latter observation suggests strongly that there is an astrophysical factor, presumably some unidentified long range force, involved. In standard physics gravitational force is the only candidate but the effects caused by the gravitational force are quite too weak. In TGD situation is different and the observations of Shnoll provide and additional piece to the picture constructed during the last decade.

1. TGD predicts that all massive bodies necessarily generate long range Coulombic dark Z^0 force. This is mathematical necessity: only the strength of this force can vary. This interaction is instantaneous: entire system behaves like single coherent whole, a comparison with a biological organism might not be far fetched. This force is however extremely weak in astrophysical length scales. TGD predicts also "massless extremals" (MEs), which can also carry classical Z^0 fields. Classical signals propagating with light velocity over cosmic distances would be in question now. There is no attenuation since essentially a radiation propagating in a wave guide is in question. Since these signals propagate along their own space-time sheets, the interaction with the cosmic microwave background does not attenuate them. The absence of dispersion means that information is preserved during the propagation of the classical field. The nondeterminism of the light-like vacuum current associated with ME at a given point of ME allows arbitrary pulse shapes and makes MEs optimal for the coding of information. These and some other properties of MEs explain with MEs are in key role in TGD inspired theory of consciousness and life [K6].

2. p-Adic fractality suggests [K4] that the dark Z^0 charge of a macroscopic object per volume defined by the p-adic length scale is essentially same irrespective of its size. This means that small objects have the highest Z^0 charge per mass ratio and respond to the classical Z^0 fields most intensely. The objects in the meter scale still have Z^0 charge densities making possible small effects. For astrophysical objects like Earth Z^0 charge is so small that it has no appreciable effects on the motion of Earth in Z^0 field of Sun. Somewhat surprisingly, dark Z^0 force is predicted to become important already in nuclear physics length scale. Dark Z^0 force is expected to be especially important in the length scale range 10 nm-2.5 μm containing the p-adic length scales of four Gaussian Mersennes.

3. Classical Z^0 force predicts variations in the rates of the radio active decays since it ultimately couples with exotic quarks of atomic nuclei at the long color bonds connecting different nucleons. This happens if the color bond is charged and thus also possesses weak gauge charge. Thus the coupling of matter to astrophysical Z^0 MEs could explain the observations of Shnoll and collaborators just as it explains the findings of Allais.

   It has been already earlier found that the beta decay of tritium (neutron decays to proton+ electron+ antineutrino) exhibits anomaly when the energy of the neutrino is very small [K14]. Also this decay exhibits periodic variations with several periods: one of them is year. This inspired the assumption that Earth's orbit is surrounded by a dark neutrino belt which has density which is not constant along the orbit and causes the effects.

4. The fluctuation of also chemical and biochemical reaction rates with the astrophysical periods lends a strong support for the hypothesis that Z^0 force is a crucial element in chemical and biological systems. For instance, classical Z^0 force explains chirality selection which is a mystery in standard physics since huge parity breaking effect is in question [K4]. In TGD inspired theory of consciousness Z^0 force is in a key role: perhaps ZEG might be some day regarded as a basic carrier of information about contents of of consciousness besides EEG. I have proposed that the quantum physics behind hearing could involves what I have used to call "cognitive neutrino pairs" and dark Z^0 force in the length scale of the cell membrane [K11]. Two decades later the idea about cognitive neutrino pairs looks unrealistic. Also dark neutrino super conductivity could define an important piece in the jigsaw of consciousness. Atoms and ions of condensed matter with anomalous weak charges can also behave as Z^0 super conductors and Z^0 magnetic cyclotron frequencies could represent important ZEG frequencies.

5. One must notice that also the spectrum for Planck constants could give a spectrum of rates due to the fact that higher order corrections to the decay rates depend on Planck constant assuming that lowest order term corresponds to $\hbar^0$, the classical approximation.

6.1.2 Several process rates and many-sheeted space-time

How to explain the fact that there are several average process rates leading to the replacement of bell curve with a many-peaked curve? One can imagine several explanations. The essential element of explanation is that classical Z^0 forces of both local and astrophysical origin affect the rates and that Z^0 field has different strengths in different parts of the system.

The first possibility is that the internal Z^0 forces vary in different parts of system. Second possibility is that external Z^0 force has effectively several strengths: this is quite possible in the many-sheeted space-time. The space-time sheets at which processes occur, can be "glued" by topological sum operation to a larger space-time sheet. If this larger space-time sheet is not always the same, the external Z^0 force varies according to which sheet the topological condensation occurs on. This gives rise to many-peaked rate curve. This many-peaked structure would be universal and highly independent of a type of process studied. Besides the p-adic length scale $L_e(k = 169)$, which corresponds to the space-time sheet of neutrinos usually, the space-time sheets characterized by the scaled up electron Compton lengths $L_e(k) = \sqrt{5}L(k)$, $k = 151, 157, 163, 167$, varying between 10 nanometers and 2.6 micrometers, are especially interesting in this respect since they correspond to the counterparts of Mersenne primes for Gaussian primes (having the form $(1 + i)^k - 1$) and are predicted to be fundamental biological length scales. Note also that the "cognitive antineutrinos" are assumed to be associated with $k = 151$ space-time sheet in TGD inspired quantum model of hearing. Note that these four p-adic length scales might correlate directly with qualitatively different levels in the evolution of life.

6.1.3 Bio-control over cosmic distances?

What is interesting is that classical Z^0 force might make possible bio-control over cosmic distances. The p-adic length scales associated with Gaussian Mersennes are in length scale 10 nm-2.5 μm suggests that objects with cell size have the highest Z^0 charge per mass ratio. Coherently changing cosmic Z^0 fields could simultaneously induce effects on bio-matter in cosmic scales: erratic interpretation of these effects as signals would lead to a conclusion that signals have propagated with super-luminal velocity. Massless extremals (MEs) accompanied by classical Z^0 fields might make possible communication and control. Cell size objects (or possibly objets with sizes between cell membrane thickness and cell size) would serve as optimal receivers. One can also speculate with the possible connection between the ubiquitous $1/f$ noise and classical Z^0 fields associated with MEs of possibly cosmic size [K10, K9]. The work done to detect signals sent by extra-terrestrial civilizations has not yielded positive results hitherto. A possible explanation is that electromagnetic signals are not used for communication purposes by advanced civilizations. One can consider also the possibility that these signals are coded into classical Z^0 fields propagating along MEs and that the mysterious $1/f$ noise contains these signals.

6.2 Torsion Fields Or Z^0 Fields

Torsion fields have been used to explain the anomalous effects related to spinning systems, in particular breaking of parity. In general relativity framework the coupling of torsion fields is quite too weak to explain these anomalies. Long ranged weak fields created by dark matter, in particular Z^0 field, can however explain these effects.

6.2.1 The concept of torsion field

The common denominator of most anomalous effects is the presence of spinning objects. This naturally led to the idea that the so called torsion field coupling to spin density could provide an explanation for the anomalous effects. In order to avoid confusion it is useful to notice that the concept of torsion has several meanings.

1. The concept of torsion and its connection with spin was introduced already by E. Cartan. It is possible to introduce torsion into Einstein's theory of gravitation as a dynamical pseudo vector field defined as the tensor dual for the antisymmetrized Christoffel symbols for non-metric connection [H14, H4, H16, H2, H6]. This however requires generaling Einstein's theory of gravitation based on metric connection having vanishing torsion. It turns that spin-torsion interaction is practically a spin-spin contact interaction and that torsion fields do not propagate in this theory. The coupling between torsion and spin is extremely weak: about 27 orders of magnitude weaker than the constant of gravitational interactions. Also a large number of nonlinear torsion theories have appeared: for instance, the torsion theory of [H7] in which the coupling constant of spin torsion interactions is of order $10^{-5} - 10^{-6}$. In TGD framework torsion in this sense is not possible since TGD relies on metric geometry.

2. Topological torsion can be defined as a topological current defined by the inner product $E \cdot B$ of electric and magnetic fields ("instanton density") proportional to the divergence of the axial vector density $T^\mu = \epsilon^{\mu\alpha\beta\gamma} A_\alpha F_{\beta\gamma}$ [B1]. The integral of this quantity over a closed 3-surface is topological invariant of em field. Topological torsion is obviously not an independent dynamical degree of freedom. In TGD the vanishing of the invariant implies that E and B are nonorthogonal in the interior of the integration volume and this in turn means that classical Z^0 field accompanies em field and also that parity breaking occurs due to the axial couplings of Z^0 field to fermions. The reason for this is very simple: induced gauge field is Abelian only if the CP_2 projection of the space-time surface is 2-dimensional. This in turn automatically implies that E and B are orthogonal for all induced gauge fields so that instanton density vanishes. Thus torsion becomes a signature for the presence of classical Z^0 fields in TGD framework.

6.2.2 The effects attributed to torsion fields can be explained in terms of classical Z^0 fields

Various experimental methods to detect torsion fields and even communication methods based on the effects of torsion fields on matter are reported [H10]. There is also a claims for evidence about nontrivial effects of torsion fields on living matter, admittedly some of them sound rather bizarre and must be taken with a big grain of salt. The experimental characteristics described in [H10] are consistent with the identification of the torsion fields with classical Z^0 fields. Z^0 classical fields are indeed in key role in TGD inspired theory of consciousness. Therefore one should be open minded in judging the reality of the claimed effects of torsion on living matter.

1. Torsion fields are generated by classical spin. If material object spins in stationary manner, torsion field is static. Same is true for the Z^0 magnetic field. Also the description of [H10] for the topology of the torsion field generated by spinning object resembles dipole magnetic field and nontrivial gyroscopic effects result when object spins in non-stationary manner. This is true also for Z^0 fields: nonstationary rotation generates by Faraday's induction law rotational Z^0 electric fields. In TGD large gravitational effects are possible since induced metric and classical gauge fields can both expressed in terms of CP_2 coordinates and the constraint of being imbeddable to $M^4_+ \times CP_2$ generates strong constraint forces.

2. According to [H10], some materials are known to serve as shields against torsion fields. In the similar manner Z^0 diamagnets serve as shields against Z^0 magnetic fields. The shielding is expected to occur in the space-time sheet labelled by the p-adic prime $p \simeq 2^k$, $k = 169$, which according to TGD inspired model of condensed matter, is neutrino super conductor of type I. Note that this space-time sheet corresponds to the space-time sheet of epithelial sheets consisting of two cell layers and is fundamental in TGD based theory of consciousness.

3. Torsion fields are predicted to be generated by any spinning material structure [H10]. For Z^0 magnetic fields in condensed matter would occur if nuclei of condensed matter carry anomalous Z^0 charges due to the charging of color bonds having exotic quarks at their ends. The quarks would couple to scaled down copies of weak bosons with weak length scale of order atomic radius.

4. Spin polarization creates torsion fields [H10] and torsion fields affect spin structure of matter. This is suggested to explain the "magnetization of water" [H10], that is the effect of ordinary magnet on biological activity of distilled water, which is diamagnetic substance. As already noticed "torsion fields" are reported to have biological effects (for references see [H10]. According to the model of [K4] water the anomalous properties of water are essentially to the dark nuclear Z^0 force and it would not be surprising if this kind of effects would occur.

5. One should have a good explanation for why classical Z^0 fields have not been observed until during last decades. That dark matter generates these fields, is certainly such an explanation.

6. Faraday's law of induction holds true for the classical Z^0 fields and effects revealing non-electromagnetic induction effect give support for the TGD based picture. One effect of this kind relates to a configuration involving two parallel conducting disks on top of each other [H8]. The lower disk rotates. If the angular velocity of the lower disk is gradually increased, the disk above it begins to rotate in opposite direction so that friction cannot cause this effect.

   A possible explanation is based on Faraday's induction law. When the rotation velocity increases, the static Z^0 magnetic field changes and gives rise to rotational Z^0 electric field, the flow lines of which circulate around the rotation axis. This in turn implies classical Z^0 Coulomb force on nuclei of the disk (assumed to have dark weak charge) accelerating them in opposite directions. The rotation of nucleons is perceived as macroscopic rotation. By the principle of least action the direction of rotation must be such that it generates Z^0 magnetic field in direction opposite to that of the original field and this means that upper disk begins to rotate in direction opposite to that of the lower disk. It is not clear whether torsion field picture could explain this effect.

7. The weight loss of a spinning gyroscope involves strong parity breaking effect and the parity breaking couplings of the classical Z^0 field readily explain the symmetry breaking. To explain the effect in picture based on torsion fields would require ad hoc assumptions about the coupling of torsion field to classical spin.

7 How To Test The Presence Of The Z^0 Force In Micrometer-millimeter Length Scale Range?

p-Adic fractality suggests that the density of dark Z^0 charge scales as $1/L_p^3$. The model for atomic nuclei predicts that the density of dark Z^0 charge is few units per atomic volume in condensed matter. This predicts that the Z^0 force is comparable to the gravitational force below length scale of order 2-20 μm.

In general, the values of G determined using Cavendish experiment have unexpectedly large range of variation although the accuracies of individual experiments are rather high. Variations of $.01 - 1$ per cent are present [E2]. There is also Cavendish experiment performed by Kruse [E12] determining gravitational constant using small rigidly connected metal spheres forming torsion pendulum. The measured value of the gravitational constant was found to be 89 per cent of the standard value! Since Z^0 force between small masses is effectively eliminated in classical Cavendish experiment, Z^0 force cannot explain these anomalies. TGD based explanation for discrepancies could be based on some other mechanism, perhaps on the redistribution of the gravitational flux of the big masses leading to effective change of the gravitational mass.

Wuppertal group [E2] has determined gravitational constant by measuring the distance between two gravitational penduli. This experiment is sensitive to classical Z^0 force between the small test masses and two variants of this experiment able to test the presence of the classical Z^0 force are discussed.

One can also consider much simpler experiment determining directly the effective gravitational force between two gravitational penduli. In the first stage of the experiment the distance from a fixed reference point to the gravitational pendulum is measured. Then second identical gravitational pendulum is introduced on the line connecting the reference point and the first pendulum and the distance is measured again. The difference of these distances allows to deduce the value of the effective gravitational constant.

k	127	131	137	139	149
L_p/m	$2.04E-12$	$8.19E-12$	$6.53E-11$	$1.31E-10$	$4.18E-9$
k	151	157	163	167	173
L_p/m	$8.33E-9$	$6.69E-8$	$5.34E-7$	$2.13E-6$	$1.71E-5$
k	179	181	191	193	
L_p/m	$1.37E-4$	$2.74E-4$	$8.85E-3$	$1.75E-2$	

Table 3: p-Adic length scales $L_p = 2^{k-127}L_{127}$, $p \simeq 2^k$, $L_{127} \equiv \frac{\pi\sqrt{5+Y}}{m_e}$, $Y = .0317$, k prime, possibly relevant to condensed matter physics.

7.1 Scaling Law For Dark Z^0 Charges

7.1.1 p-Adic length scale hypothesis

p-Adic length scale hypothesis states that p-adic primes which correspond to with $p \simeq 2^k$, k power of prime are physically preferred ones. **Table 3** gives the list of p-adic length scales relevant for condensed matter physics. Note that the length scales are determined only up to some numerical constant. The fixing of $L_e(151)$ to be the thickness of cell membrane about 10^{-8} meters is promising physically sensical manner to fix the overall scale factor uniquely.

Scaling hypothesis provides a quantitative model for the density of dark matter at various p-adic length scales and follows naturally from p-adic fractality hypothesis. Scaling hypothesis states that the net Z^0 charge to nuclear Z^0 charge ratio denoted by $1/\sqrt{\epsilon_Z(p)}$ scales as $1/L_p^3$, where L_p is the p-adic length scale associated with the massive object and related to the size of the massive object by some numerical coefficient not too far from one.

7.1.2 Modification of the effective gravitational constant

The scaling law for Z^0 charge implies definite prediction for the effective gravitational force between two sufficiently small objects. Z^0 repulsion leads to the reduction of the effective gravitational force between small test masses. The value of the effective gravitational constant for the interaction between small test particles is

$$G_{eff} = (1-\frac{F_Z}{F_G})G \ . \tag{7.1}$$

where F_Z and F_G denote Z^0 and gravitational forces between test masses. Define L_w, as the p-adic length scale associated with nuclear exotic weak bosons. According to [K14], one has $L_w = nL_e(113)/v_0 \simeq xnL_e(135)$, $x \in [1,2]$. For $n = 1$ this length scale is in the range 1-2 Angstrom and for $n = 3$ in the range 3-6 Angstrom (this option seems to hold true in water and living matter).

Using this input one obtains an explicit formula for F_Z/F_G as

$$\begin{aligned}
\frac{F_Z}{F_G} &= \alpha_Z Q_Z^2(n)\frac{1}{Gm_p^2}\frac{N^2}{A^2}(\frac{L_w}{L_p})^6 \ , \\
\alpha_Z Q_Z^2(n) &= \frac{\alpha_{em}Q_Z(n)^2}{sin(\theta_W)cos(\theta_W)} \ , \\
Q_Z(n) &= \frac{1}{4}+sin^2(\theta)_W \simeq 1/2 \ , \\
sin^2(\theta_W) &\simeq 0.23 \ .
\end{aligned} \tag{7.2}$$

$Gm_p^2 \simeq 10^{-38}$ is the ratio of proton mass squared to Planck mass squared (units $\hbar = 1$, $c = 1$ are used). α_Z is Z^0 coupling constant strength, $\alpha \simeq 1/137$ is fine structure constant and θ_W denotes Weinberg angle, m_p is proton mass and A denotes mass per atomic volume a of atom or molecule in question. $N \times a^3/L^3(k)$ is the nuclear anomalous weak isospin per atomic volume using neutron's weak isospin $Q_Z(n)$ as a unit and assuming p-adic fractality. $0 \leq N << A$ is expected to hold true since nuclear anomalous charge corresponds to weakly charged color bonds carrying $N = \pm 2$ units of neutrino weak isospin. The dependence of the force ratio is very sensitive to L_p: a scaling by a factor of 2 implies a reduction by a factor 2^{-6}.

This gives an estimate for the length scale L_{cr} at which Z^0-and gravitational forces have same strength.

$$L_{cr} = \left[\alpha_Z Q_Z^2(n)\frac{N^2}{A^2}\frac{1}{Gm_p^2}\right]^{1/6} L_w \ . \tag{7.3}$$

Numerical estimate gives

$$L_{cr} \simeq .07 \times (\frac{N}{A})^{1/3} \times \frac{L_w}{L_e(139)} \ mm \ . \tag{7.4}$$

Consider Fe ($A = 56$) as an example. For $N = 1$ (just an ad hoc assumption) and $n = 1$ giving $L_w = xL_e(135)$, the length scale in question would be $L_{cr} = 4.85x$ μm for so that cell length scale would be the critical length scale. For $n = 3$ one would have $L_{cr} = 14.5x$ μm. By p-adic length scale hypothesis the nearest physically favored p-adic length scale above L_{cr} corresponds to $L_e(169) = 5$ μm for $n = 1, x = 1$ and the nearest p-adic length scale below to $L_e(167) = 2.5$ μm and corresponds to the largest Gaussian Mersenne in the sequence of Gaussian Mersennes $(1+i)^k - 1$ labelled by $k = 151, 157, 163, 167$. Thus Gaussian Mersennes would correspond to length scales for which the dark weak force wins the gravitational force. The change of the sign of the effective gravitational coupling constant is so dramatic effect that it should certainly reveal the presence of the new force.

The critical length scale is not very sensitive to N/A. For water with $A = 18$ and $n = 3$ one would obtain using the same parameter values the result $L_{cr} = 21.2$ μm which is slightly above $L_e(173) = 20$ μm.

Interestingly, there is a little bit more than rumor that Eötwos group [E5] has found below 100 microns evidence for a deviation of the strength of gravitational force from the Newtonian prediction at 4 sigma confidence level. The group is still performing additional tests before publishing the result. The effect is weakening of gravitational force and could thus be explained in terms of dark Z^0 force. What is also interesting that M-theory inspired models tend to predict that gravitational force gets stronger at these distances [E6].

7.2 How To Directly Test The Presence Of Classical Z^0 Force?

Standard Cavendish experiment [E2] is based on the measurement of the torsion angle of a torsion pendulum. Small test masses m are connected by a bar and this structure hinges from the middle point of the bar by a thread. The introduction of the large masses located symmetrically with respect to the origin causes a torque and the value of the gravitational constant can be deduced from the value of the torsion angle. This experiment does not reveal the classical Z^0 force since small masses are connected by bar fixing their mutual distance and thus effectively eliminating classical Z^0 force.

To reveal the presence of the classical Z^0 force, one should use free gravitational penduli and measure precisely the distance between them in equilibrium position with and without external masses to see whether the classical Z^0 interaction between the small test masses is present. Wuppertal group [E2] has applied this method to determine the value of gravitational constant. Thus it seems that the technology making possible to test TGD predictions might already exist.

One can consider two variants of the Wuppertal experiment [E2].

1. Large masses are located symmetrically on the opposite sides of the plane of penduli on the line bisecting the line connecting the penduli. Therefore the net gravitational force caused by them is parallel to the axis connecting the small masses and tends to bring the small masses closer to each other.

2. Large masses are located on the line connecting small masses and the gravitational force tends to pull small masses apart from each other.

One can however consider much simpler experiment. In the initial situation there is only single pendulum and the distance from a fixed reference point to pendulum is measured. Then second identical pendulum is introduced on the axis connecting reference point and the first pendulum and the distance to the first pendulum is measured again. From the change of the distance the value of the effective gravitational constant is deduced. The sign of the distance increment tells also whether the force between the penduli is attractive or repulsive. A practical manner to perform the experiment is perhaps following.

1. Constraint the second pendulum to the configuration $\theta = -\pi$ so that the pendulum points upwards where its interaction with the first pendulum is much weaker than in equilibrium position.

2. Remove the constraint and allow the pendulum to go to the equilibrium position $\theta \simeq 0$.

7.2.1 Direct measurement of the classical Z^0 force

Let z-axis be in the direction of Earth's gravitational field. Let the two gravitational penduli have length l and mass m. Assume that the suspension points have transversal distance d. It is convenient to choose the coordinates in such a way that penduli are at x-axis and that the x-coordinates for the points of suspension are $x = -d/2$ and $x = d/2$. In the first situation there is only one pendulum at $x = d/2$ and distance to it is measured from some point of x-axis with coordinate $X > d/2$. The second pendulum is introduced at $-d/2$ and the change of the distance of the first pendulum to a fixed reference point is measured.

The penduli are affected only by Earth's gravitational force and possibly also by classical Z^0 force which only renormalizes the effective gravitational coupling constant: $G \rightarrow XG$. The potential energy is thus given by

$$\begin{aligned} V &= -X\frac{Gm^2}{r_{12}} + mgl\left[cos(\theta_1) + cos(\theta_2)\right] \ , \\ r_{12} &= d + l(sin(\theta_1) + sin\theta_2)) \ . \end{aligned} \tag{7.5}$$

θ_i denote the deviations of the penduli from the vertical direction defined by the direction of g. Equilibrium position corresponds to symmetric configuration $\theta_1 = \theta_2$ and the requirement that potential is minimum determines the values of θ_i. Since extremely small deviations from $\theta_i = 0$ are in question, one can linearize with respect to θ_i. The result is

$$\begin{aligned} \theta_1^0 &= \frac{XG_1}{1 + 4G_1 w} \ , \\ G_1 &= \frac{g_1}{g} = \frac{m}{M_E}\frac{R_E^2}{d^2} \ , \\ w &= \frac{l}{d} \ . \end{aligned} \tag{7.6}$$

If one can directly measure the distance of the first pendulum from a point of x-axis both in absence and presence of the second pendulum, it is possible to deduce the value of θ_1 from the relation

$$\Delta x = l\theta_1^0 \ ,$$

and from this to deduce the value of the parameter X. In excellent approximation θ_1 is given by

$$\theta_1 \simeq Xg_1/g = X\frac{R_E^2}{d^2}\frac{m}{M_E} \ .$$

Here $R_E \simeq 6.6 \times 10^6$ meters is the radius of Earth and $M_E \simeq 6 \times 10^{24}$ kg is the mass of Earth. For $d = .1$ meters and $m = 10^{-2}$ kg this gives $\theta_1 \sim 6 \times 10^{-9}$ radians. If one can make the length l of the pendulum large, the value of Δx could perhaps be made so large that it becomes detectable. For $l = 1$ m the deviation would be 10^{-8} meters for $X = 1$. Note that the value of θ_1 does not depend on the mass of the pendulum.

If classical Z^0 force is present and obeys scaling law, the value of θ_1 can change its sign and, behaving as $1/L^6$ as a function of the size L of the test mass, can increase dramatically for very small test mass sizes. Also this could make the experiment feasible. The mere decrease of the distance would immediately tell that the net force is repulsive. One must however consider the possibility that the p-adic prime characterizing the pendulum is not determined by the size of the mass blob but by the size of the entire pendulum and could thus be much larger. In this case no dramatic effects are to be expected.

7.2.2 Introduction of the large masses

The initial situation of the experiment corresponds to the presence of two gravitational penduli on x-axis at points $x = -d/2$ and $x = d/2$. This situation was already treated. Larger masses M are introduced. There are two ways to introduce them.

1. Cm coordinates of the large masses are on the plane determined by penduli. The coordinates for their positions are either

$$\begin{aligned} (x,y,z) &= (x_1,0,h) \ , \\ (x,y,z) &= (-x_1,0,h) \ . \end{aligned} \tag{7.7}$$

2. Cm coordinates of the large masses are on y-axis and symmetrically related to the plane of the penduli

$$\begin{aligned} (x,y,z) &= (0,h,0) \ , \\ (x,y,z) &= (0,-h,0) \ . \end{aligned} \tag{7.8}$$

The distance of the large mass from nearby small mass is $r = \sqrt{h^2 + (x - d/2)^2}$ and the difference for x-coordinates of M and m is $r_x = x - d/2$. The parameters l, d, r_x and h characterize the geometry of the arrangement. Convenient dimensionless parameters are following

$$\begin{aligned} &u \equiv cos(\psi) = \tfrac{r_x}{r} \ , \quad v \equiv \tfrac{l}{r} \ , \quad w = \tfrac{l}{d} \ , \\ &r_x = x - d/2 \ , \quad r = \sqrt{h^2 + (x - d/2)^2} \ . \end{aligned} \tag{7.9}$$

There are two parameters, G_1 and G_2 characterizing gravitational forces experienced by small mass m. G_1 characterizes the acceleration caused by second small mass m and G_2 characterizes the acceleration caused by the nearest big mass M. These parameters are given by

$$\begin{aligned} G_1 &= \frac{g_1}{g} = \frac{m}{M_E}\frac{R_E^2}{d^2} \ , \\ G_2 &= \frac{g_2}{g} = \frac{M}{M_E}\frac{R_E^2}{r^2} \ , \\ r &= \sqrt{h^2 + (x - d/2)^2} \ . \end{aligned} \tag{7.10}$$

The deviations of the gravitational force between small test masses caused by the classical Z^0 force could affect the measured value of G only if the gravitational force between the small is sufficiently large. The parameter which turns out to measure the importance of the gravitational force between small masses is given by

$$\begin{aligned} p &\equiv \frac{G_1}{G_2 u} , \\ u &\equiv \frac{r_x}{r} \equiv cos(\psi) \ . \end{aligned} \tag{7.11}$$

Here ψ is the direction angle of the position of large mass M. It is convenient to characterize the effective gravitational force between small test particles by the parameter

$$X = \frac{G_{eff}(m,m)}{G} \ .$$

This reduction of gravitational force between small test masses causes change of the gravitational constant as given by Wuppertal experiment. The change is not necessarily large. The ratio

$$Y = \frac{G_{meas}}{G}$$

between the measured and actual gravitational constants is a convenient experimental parameter to describe the effect of Z^0 force. The intention is to derive the formulas relating to each other the parameters X and Y.

7.2.3 The two variants of the Wuppertal experiment

Consider now the situation when big masses are brought near the small masses in the two ways corresponding to two versions of the Wuppertal experiment. The potential energy V of the previous case is replaced with $V + V_{int}$, where V_{int} is ordinary gravitational potential energy to which Z^0 force does not contribute if the size of the test masses is large enough.

1. For the first variant of Wuppertal experiment one has

$$\begin{aligned} V_{int} &= -\frac{GmM}{r_{1a}} - \frac{GmM}{r_{2a}} , \\ r_{1a} &= \sqrt{h^2 + (r_x - lsin(\theta_1))^2} , \\ r_{1b} &= \sqrt{h^2 + (r_x - lsin(\theta_2))^2} , \\ r_x &= x - d/2 \ . \end{aligned} \tag{7.12}$$

   The interaction energy of small mass with the second large mass is neglected for simplicity.

2. For the second variant of Wuppertal experiment one has

$$\begin{aligned} V_{int} &= -\frac{GmM}{r_{1a}} - \frac{GmM}{r_{1b}} - \frac{GmM}{r_{2a}} - \frac{GmM}{r_{2b}} , \\ r_{1a} &= r_{1b} = \sqrt{h^2 + (r_x - lsin(\theta_1))^2} , \\ r_{2a} &= r_{2b}\sqrt{h^2 + (r_x - lsin(\theta_2))^2} , && (7.13) \\ r_x &= -d/2 \ . && (7.14) \end{aligned}$$

   The new equilibrium position corresponds to $\theta_1 = \theta_2$ with

$$\begin{aligned} &\theta_1^1 = \frac{XG_1 - kG_2 u}{1+4XG_1 w + kG_2 f} \ , \quad f \equiv (1-3u^2)v \ , \\ &u \equiv cos(\psi) = \frac{r_x}{r} \ , \quad v \equiv \frac{l}{r} \ , \quad w = \frac{l}{d} \ . \end{aligned} \tag{7.15}$$

The parameter k specifies the Wuppertal experiment. $k = 1$ for arrangement 1) in the approximation that force between small mass and second large mass can be neglected. $k = 2$ for the arrangement b) since gravitational force between small mass and large masses is doubled.

The change of the equilibrium position of pendulum when large masses are brought in, is characterized by the difference $\Delta\theta = \theta_1^1 - \theta_1^0$ and given by

$$\begin{aligned} \Delta\theta &= \theta_1^1 - \theta_1^0 \\ &= \frac{XG_1 - kG_2u}{1+4XG_1w+kG_2f} - \frac{XG_1}{1+4G_1w} \ . \end{aligned} \tag{7.16}$$

Note that version 2) of the Wuppertal experiment is obtained from version 1) by the replacements $G_2 \rightarrow 2G_2$ and $r_x = x - d/2 \rightarrow -d/2$.

7.2.4 How the measured value of G is affected by Z^0 force in Wuppertal experiments?

Consider now how the value of G is effected by the presence of the classical Z^0 force. If one does not take into account the presence of the Z^0 force, one obtains for $\Delta\theta$ the expression with G replaced by $G_{eff} = YG$:

$$\begin{aligned} \Delta\theta &= \theta_1^1 - \theta_1^0 \\ &= \frac{YG_1 - YkG_2u}{1+4YG_1w+YkG_2f} - \frac{YG_1}{1+4YG_1w} \ , \\ Y &= \frac{G_{meas}}{G} \ . \end{aligned} \tag{7.17}$$

One can solve Y in terms of X explicitly by equating the two expressions for $\Delta\theta$ from the resulting second order polynomial equation.

$$\begin{aligned} & Y^2A_2 + YA_1 + A_0 = 0 \ , \\ & A_2 = G_1kG_2\left[4(wu+f) - \Delta\theta(4w\tfrac{G_1}{kG_2} + f)\right] \ , \\ & A_1 = kG_2\left[u + \Delta\theta(4\tfrac{G_1w}{kG_2} + 4w + f)\right] \ , \\ & A_0 = \Delta\theta \ . \end{aligned} \tag{7.18}$$

Because of the numerical instabilities ($\Delta\theta$ is difference of two very nearly identical quantities which are sums over quantities with hugely different orders of magnitude it is however better to solve Y iteratively. One can write $\Delta\Theta$ in the two forms

$$\begin{aligned} \Delta\theta(Y) &\simeq -kG_2u\left[\frac{Y}{1+Y(B1-kG_2f)} + Y^2\frac{G_1}{(1+YB_1)^2}\frac{f}{u}\right] \ , \\ \Delta\theta(X) &\simeq -kG_2u\left[\frac{1}{1+X(B1-kG_2f)} + \frac{G_1X}{(1+XB_1)^2}\frac{f}{u}\right] \ . \end{aligned} \tag{7.19}$$

$\Delta\theta(Y) = \Delta\theta(X)$ gives equation for Y:

$$\begin{aligned} & Y = A(B+C+D) \ , \\ & A = 1+Y(B1-kG_2f) \ , \quad B = \tfrac{1}{1+X(B1-kG_2f)} \ , \quad C = \tfrac{G_1X}{(1+XB_1)^2}\tfrac{f}{u} \ , \\ & D = -Y^2\tfrac{G_1}{(1+YB_1)^2}\tfrac{f}{u} \ , \qquad B_1 = 4G_1w \ . \end{aligned} \tag{7.20}$$

One can solve this iteratively by substituting $Y(n)$ to the righthand side to obtain $Y(n+1)$.

Numerical experimentation show that Y is rather stable against variations of X. Reduction of X makes Y larger than one in both cases. It seems that deviations of G from its standard value caused by classical Z^0 force are rather small.

1. For the variant 1) of the Wuppertal experiment, the calculation using $m = .005$ kg, $M = .10$ kg, $l = .3$ meters, $d = .001$ meters, $h = .5$ meters and $x = .1$ meters gives only 4.2 percent increase of the measured G for $X = -10^3$!

2. For the variant 2) of Wuppertal experiment with same parameter valued ($x = 0$), one obtains 6.5 per cent increase of the gravitational constant.

8 Appendix: Allais Effect As Manifestation Of Classical Z^0 Force?

Although it seems now clear that Allais effect can be understood as gravitational effect, it makes sense to keep the earlier model explaining Allais effect as a manifestation of classical Z^0 force.

In 1954 Allais performed experiments in which he studied the behavior of paraconic pendulum by releasing the pendulum every 14 minutes and determining the normal of the plane of oscillation [E3, E10, E13, E14]. Earth's rotation causes (apparent) rotation of this plane with velocity of.19 degrees per minute. The experiment happened to overlap 1954 solar eclipse. During the eclipse the pendulum took an unexpected turn, changing the angle θ defining the plane of oscillation by θ about 13.5 degrees. Allais repeated the experiments in 1959 and found similar result. The anistropy of g implied by the result is about $\Delta g/g \simeq 3 \times 10^{-6}$, which looks very small as compared to the large value of θ. The explanation of apparent discrepancy is that Foucault pendulum amplifies very effectively small anisotropies for g for small values of oscillation amplitude and is therefore ideal for detecting these anomalies. During the last total eclipse August 11 1999 NASA repeated the experiment but the processing of the data is still going on. Allais observed also anomalies with periods of 24 and 25 hours in the behavior of oscillating paraconic pendulum.

8.1 Screening Of Dark Z^0 MEs Emitted By Sun As An Explanation Of Allais Effect?

In TGD framework one can imagine a possible explanation for the effect claimed by Allais in terms of classical Z^0 force and partial channelling of Z^0 electric gauge flux from "standard" space-time sheet to some other space-time sheets.

1. According to the TGD based models of atomic nuclei and condensed matter [K14, K4] a Foucault pendulum could have have dark Z^0 charge. The modification of the Z^0 interaction of Foucault pendulum with Sun caused by the location of Moon between Sun and Earth could perhaps explain Allais effect. Dark neutrino cloud surrounding Sun is one possible source of Z^0 force. It seems that Z^0 Coulomb force, although present, is quite too weak. It is however possible that the interaction is mediated by Z^0 MEs, which carry Bose Einstein condensates of essentially massless dark Z^0 bosons behaving like laser beams so that the Z^0 field does not suffer $1/r^2$ decay. What would happen that the direction of the effective gravitational force on the surface of Earth changes due to Z^0 force of Sun so that also the direction of the plane of oscillation is changed. Since the effect becomes visible only during eclipse, screening of the Z^0 beam by absorption or is most probably involved but one cannot exclude the possibility that Moon acts amplifies the beam via induced emission.

2. If the Z^0 electric field of ME induces the effect the direction of force is orthogonal to the line connecting Earth to Sun. If the rotational motion of Sun causes the emission of Z^0 MEs and the resulting Z^0 field depends on the direction of Z^0 current of Sun in the same manner as in ordinary electrodynamics, the Z^0 electric field given bey the time derivative of Z^0 vector potential is proportional to the Z^0 current at the surface of the emitting region and thus tangential to the plane of the orbit of Earth around Sun. Hence Z^0 electric field is in the orbital plane and induces a force which is tangential to Earth's surface and almost orthogonal to the Earth's gravitational field (the tilting of Earth's rotating axis induces small non-orthogonality). No effect is predicted if the rotation plane of the pendulum is in East-West direction and maximal effect results when the pendulum is in North-South direction.

3. The oscillation frequency of the pendulum and oscillation plane should exhibit day-night variation since also Earth modifies Z^0 beam and Earth's gravitational field are opposite at opposite sides of Earth. In fact, Allais has detected periodic variations with period of 24 and 25 hours in the behavior of the Foucault pendulum [E13, E14]. 24 hour period would be naturally due to the modification of Z^0 beam by Earth and the 25 hour period could be due to the rotation of moon which means that the Sun at moon are at same line with a period which is slightly longer than 24 hours. Instead of 2π Earth must rotate the angle $2\pi + \Delta\Phi$, $\Delta\Phi \sim \frac{2\pi}{30} = 12$ degrees and thus the period is $T + \Delta T$, $\Delta T = \frac{12}{360} \times 24 = 4/5$ hours.

8.2 Quantitative Picture

Consider now a more quantitative formulation of the model.

1. The force experienced by the pendulum is

$$\begin{aligned} \overline{F} &= \left[m\overline{g} + \overline{f}_Z\right]_{\perp} \ , \\ \overline{f}_Z &= \overline{f}_Z \ . \end{aligned} \tag{8.1}$$

   where $\overline{f}_Z$ refers to the net Z^0 force caused by Sun. The subscript "$\perp$" refers to the projection to the plane orthogonal to the direction of the pendulum.

2. If the screening caused by Moon by the absorption of Z^0 MEs, Moon effectively creates a shadow, whose size at the surface of Earth is essentially the shadow of Moon to Earth created by light from Sun. This means that effect is seen only during solar eclipse. The modification caused by Moon does not affect the direction of $\overline{f}_Z$, which is fixed completely by the geometry of the Z^0 beam and the proposed mechanism generating it. The modification can be parameterized using coefficient ϵ characterizing the reduction/increase of the magnitude of $\overline{f}_Z$:

$$\overline{f}_Z \rightarrow (1-\epsilon)\overline{f}_Z \ .$$

   For absorption ϵ is positive and negative for amplification.

3. Let $\overline{t}$ denote the unit vector in the direction of the vector connecting the point of suspension for the pendulum and the point at which pendulum is released. Let $\overline{n}$ denote the direction of $\overline{F}$. The normal for the plane of oscillation is given in the direction of $\overline{e} = \overline{n} \times \overline{t}$. When Moon is on the line of sight connecting Sun and Moon, the modification of $\overline{f}_Z$ is largest. The change of the normal of the oscillation plane can be found from the change of the vector $\overline{e}$:

$$\begin{aligned} \overline{e} &\rightarrow \overline{e}_1 = \overline{e} + \Delta\overline{e} \ , \\ \Delta\overline{e} &= \Delta\overline{n} \times \overline{t} \ . \end{aligned} \tag{8.2}$$

   $\Delta\overline{n}$ can be calculated from a detailed model for the screening of the Z^0 field of the neutrino cloud caused by the presence of the Moon. The value of the angle θ is given by

$$sin(\theta) = \frac{|\overline{e}_1 \times \overline{e}|}{|\overline{e}_1||\overline{e}|} \ . \tag{8.3}$$

   The upper bound for $sin(\theta)$ is

$$|sin(\theta)| \leq \frac{|\overline{\Delta g} \times \overline{t}|}{|\overline{g}||\overline{t}|} \ . \tag{8.4}$$

   From this upper bound it is clear that if the release angle for pendulum is small so that the cross product $|\overline{g} \times \overline{t}|$ is small, gravitational anisotropy is amplified dramatically and Foucault pendulum is thus ideal method for detecting gravitational or other anomalies.

According to the experiments of Allais [E13, E14] the following estimate holds true:

$$\frac{\epsilon f_Z}{mg} \simeq 3\times 10^{-6} . \quad (8.5)$$

For MEs the $\overline{f}_Z$ is approximately orthogonal to $\overline{g}$ so that the strength of gravitational field effectively increases in the absence of screening. Since the change of the effective gravitational force of Earth is $-\epsilon f_Z(Sun)$, effective g is predicted to increase if ϵ is positive as it is for screening.

The value of the parameter ϵ can be estimated by studying the time dependence of $\delta g/g$ explaining the anomalous behavior of Foucault period with a period of 24 hours observed by Allais [E13, E14]. The dependence of the size of the effect on the size and physical properties of the pendulum makes it possible to test further the model.

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