Article

Cosmic String Model for Formation of Galaxies, & DNA Structure

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Abstract

The view about the role of new nuclear physics predicted by TGD in the model of solar interior gives excellent guidelines for attempts to develop a more detailed understanding about TGD counterparts of blackholes as volume filling flux tube tangles. One ends up to rather detailed picture making correct predictions about minimum radii of blackholes and neutron stars. The idea about ordinary stars as blackhole like objects emerges. The standard blackhole thermodynamics is replaced by two thermodynamics. The first thermodynamics is assignable to the flux tubes as string like entities having Hagedorn temperature T_H as maximal temperature. The second thermodynamics is assignable to gravitational flux tubes characterized by the gravitational Planck constant h_{gr}. Cosmic strings are assumed to form a fractal hierarchy and that in TGD inspired biology cosmic strings thickened to monopole flux tubes are behind various linear biomolecules organized around them as ordinary matter. This leads to ask whether DNA double strand and the organization of DNA double strands to chromosomes might be more general phenomenon. Chromosomes consist of 4 strands, which allows to ask whether something similar happens even at the level of superclusters and that the topology of quadrupole field is involved.

Keywords: Cosmic string model, galaxy, formation, DNA strand, TGD framework.

1 Introduction

The view about the role of new nuclear physics predicted by TGD in the model of solar interior [25] gives excellent guidelines for attempts to develop a more detailed understanding about TGD counterparts of blackholes as volume filling flux tube tangles.

1.1 Brief description of the model for for the formation of galaxies and stars

TGD based cosmology predicts that the primordial cosmology was dominated by cosmic strings identified as 4-surfaces having 2-D M^4 projection in $H = M^4 x CP_2$. CP_2 projection is a complex surface of CP_2. The dimension of M^4 projection is unstable against perturbations and during cosmological evolution the M^4 projection thickens. This leads to a model for the formation of galaxies as tangles along cosmic strings in turn containing stars and even planets as sub-tangles.

1. Twistor lift of TGD [15] predicts that cosmological constant at the level of space-time surface (to be distinguished from that associated with GRT limit of TGD) is length scale dependent. This solves the basic problem caused by the huge value of cosmological constant in the very early Universe. In zero energy ontology length scale dependent Λ having spectrum coming in some negative powers of 2 characterizes the space-time sheets assignable to individual system and the corresponding causal diamond (CD) and is determined by its p-adic length scale.

   For instance, Sun has its own cosmological constant predicted by the model solving the puzzle due to larger abundances obtained in solar-seismological determinations than in spectroscopic and meteoritic determinations. Dark nuclear states of nuclei inside solar core contribute also to the nuclear abundances [25].

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2. The energy of flux tubes consists of Kähler magnetic energy and volume energy. Quantum classical correspondence strongly suggests that this energy is identifiable as dark matter even for minimal value of h_{eff}.

3. Phase transitions reducing the value of cosmological constant are possible. Cosmic strings (or rather their M^4 projections) start to thicken and lose magnetic energy by transforming to ordinary matter. This is analogous to the decay of the inflaton field to matter. This generates Einsteinin space-time with space-time surfaces having large and increasing 4-D M^4 projection. Flux tubes and cosmic strings are however still present.

   The expansion of flux tubes in phase transitions reducing Λ gives rise to a jerk-wise accelerated expansion at the level of astrophysical objects. For given phase transition the accelerated expansion eventually stops since the expansion increases volume energy. The expansion periods however repeat being induced by phase transitions reducing length scale dependent quantized cosmological constant Λ associated with the volume action coming as powers of 2 and making flux tubes unstable against thickening and transformation of magnetic energy to ordinary matter. The recent accelerated expansion corresponds to this kind of period being thus analogous to inflation and is predicted to stop since volume energy increases. The expansion rate is predicted to oscillate so that the expansion takes place as jerks and there is evidence for this [2] (see (`http://tinyurl.com/oqcn2hp`) discussed from TGD point of view in [13].

4. In particular, the TGD counterpart of inflation would have led from cosmic string dominated primordial cosmology in which Einsteinian space-time does not make sense to a radiation dominated phase in which Einsteinian space-time makes sense. Expanding Earth model [21] allowing to understand Cambrian Explosion is one application of TGD based quantum cosmology.

1.2 The notion of length scale dependent cosmological constant

In this section the notion of length scale dependent cosmological constant is considered in more detail. TGD predicts that cosmological constant Λ characterizing space-time sheets is length scale dependent and depends on p-adic length scale. Furthermore, expansion would be fractal and occur in jerks. This is the picture that twistor lift of TGD leads to [15].

Quite generally, cosmological constant defines itself a length scale $R = 1/\Lambda^{1/2}$. $r = (8\pi)^{1/4}\sqrt{Rl_P}$ - essentially the geometric mean of cosmological and Planck length - defines second much shorter length scale r. The density of dark energy assignable to flux tubes in TGD framework is given as $\rho = 1/r^4$.

In TGD framework these scales corresponds two p-adic length scales coming as half octaves. This predicts a discrete spectrum for the length scale dependent cosmological constant Λ [15] . For instance, one can assign to ..., galaxies, stars, planets, etc... a value of cosmological constant. This makes sense in many-sheeted space-time but not in standard cosmology.

Cosmic expansion is replaced with a sequence of fast jerks reducing the value of cosmological constant by some power of 2 so that the size of the system increases correspondingly. The jerk involves a phase transition reducing Λ by some negative power of 2 inducing an accelerating period during which flux tube thickness increases and magnetic energy transforms to ordinary matter. Thickening however increases volume energy so that the expansion eventually halts. Also the opposite process could occur and could correspond to a "big" state function reduction (BSFR) in which the arrow of time changes.

An interesting question is whether the formation of neutron stars and super-novas could involve BSFR so that these collapse phenomena would be kind of local Big Bangs but in opposite time direction. One can also ask whether blackhole evaporation could have as TGD analog BSFR meaning return to original time direction by a local Big Bang. TGD analogs of blackholes are discussed in [22].

Evidence for the anisotropy of the acceleration of cosmic expansion has been reported (see `http://tinyurl.com/rx4224f`). Thanks to Wes Johnson for the link. Anisotropy of cosmic acceleration would fit with the hierarchy of scaled dependent cosmological constants predicting a fractal hierarchy

of cosmologies within cosmologies down to particle physics length scales and even below. The phase transitions reducing the value of Λ for given causal diamond would induce accelerated inflation like period as the magnetic energy of flux tubes decays to ordinary particles. This would give a fractal hierachy of accelerations in various scales.

Consider now some representative examples to see whether this picture can be connected to empirical reality.

1. Cosmological constant in the length scale of recent cosmology corresponds to $R \sim 10^{26}$ m (see `http://tinyurl.com/k4bwlzu`). The corresponding shorter scale $r = (8\pi)^{1/4}\sqrt{Rl_P}$ is identified essentially as the geometric mean of R and Planck length l_P and equals to $r \sim 4 \times 10^{-4}$ m: the size scale of large neuron. This is very probably not an accident: this scale would correspond to the thickness of monopole flux tubes.

2. If the large scale R is solar radius about 7×10^8 m, the short scale $r \simeq 10^{12}$ m is about electron Compton length, which corresponds to p-adic length scale $L(127)$ assignable to Mersenne prime $M_{127} = 2^{127} - 1$. This is also the size of dark proton explaining dark fusion deduced from Holmlid's findings [16, 17]: this requires $h_{eff} \sim 2^{12}$!

   Remark: Dark proton sequences could be neutralized by a sequence of ordinary electrons locally. This could give rise to analogs of atoms with electrons being very densely packed along the flux tube.

   The prediction of the TGD based model explaining the 10 year old puzzle related to the fact that nuclear abundances in solar interior are larger than outside [25] (see `http://tinyurl.com/y38m54ud`) assumes that nuclear reactions in Sun occur through intermediate states which are dark nuclei. Hot fusion in the Sun would thus involve the same mechanism as "cold fusion". The view about cosmological constant and TGD view about nuclear fusion lead to the same prediction.

3. If the short scale is p-adic length $L(113)$ assignable to Gaussian Mersenne $M_{G,113} = (1+i)^{113} - 1$ defining nuclear size scale of $r \sim 10^{-14}$ m, one has $R \sim 10$ km, the radius of a typical neutron star (see `http://tinyurl.com/y5ukv2wt`) having a typical mass of 1.4 solar masses.

   A possible interpretation is as a minimum length of a flux tube containing sequence of nucleons or nuclei and giving rise to a tangle. Neutron would take volume of about nuclear size - size of the magnetic body of neutron? Could supernova explosions be regarded as phase transitions scaling the stellar Λ by a power of 2 by making it larger and reducing dramatically the radius of the star?

4. Short scale $r \sim 10^{-15}$ m corresponding to proton Compton length gives R about 100 m. Could this scale correspond to quark star (see `http://tinyurl.com/y3n78tjs`)? The known candidates for quark stars are smaller than neutron stars but have considerably larger radius measured in few kilometers. Weak length scale would give large radius of about 1 cm. The thickness of flux tube would be electroweak length scale.

Starting from this picture, one ends up to rather detailed picture making correct predictions about minimum radii of blackholes and neutron stars. The idea about ordinary stars as blackhole like objects emerges naturally since flux tubes are universal objects in TGD Universe and could be also inspired by the fashion of dualizing everything to blackholes.

The standard blackhole thermodynamics is replaced by two thermodynamics. The first thermodynamics is assignable to the flux tubes as string like entities having Hagedorn temperature T_H as maximal temperature. The second thermodynamics is assignable to the gravitational flux tubes characterized by the gravitational Planck constant h_{gr}: Hawking temperature T_B is scaled up by the ratio $\hbar_{gr}/\hbar$ to $T_{B,D}$ and is gigantic as compared to the ordinary Hawking temperature but the intensity of dark Hawking radiation is extremely low.

The condition $T_H = T_{B,D}$ for thermodynamical equilibrium fixes the velocity parameter $\beta_0 = v_0/c$ appearing in the Nottale formula for $\hbar_{gr}$ and suggests $\beta_0 = 1/h_{eff}$ for the dark nuclei at flux tubes

defining star as blackhole like entity in TGD sense. This also predicts the Hagedorn temperature of the counterpart of blackhole in GRT sense to to be hadronic Hagedorn temperature assignable to the flux tube containing dark nuclei as dark nucleon sequences so that there is a remarkable internal consistency. In zero energy ontology (ZEO) quasars and galactic blackholes can be seen as time reversals of each other.

The cosmological time anomalies such as stars older than the Universe can be understood. In ZEO the time evolution for the zero energy states associated with causal diamonds (CDs) by sequences of small state function reductions (weak measurements) gives rise to conscious entity, self. Self dies and reincarnates with an opposite arrow of time in big (ordinary) state function reduction reversing the arrow of time. These reincarnations define kind of universal Karma's cycle. If the Karma's cycle leaves the sizes of CDs bounded and their position in M^4 unaffected, quantum dynamics reduces to a local dynamics inside CDs defining sub-cosmologies. In particular, the age distributions and properties of stars depend only weakly on the value of cosmic time - stars older than the Universe become possible in standard view about time.

The flux tube picture about galaxies and larger structures is discussed with application to some anomalies strongly suggesting the presence of coherence in scales of even billion light years. Also "too" fast spinning galaxies are discussed. The local galaxy supercluster Laniakea is discussed in the flux tube picture as a flux tube tangle in scale of .5 Gly.

2 Blackholes, quasars, and galactic blackholes

I have discussed a model of quasars in [22] (see `http://tinyurl.com/y2jbru4k`) . The model is inspired by the notion of MECO and proposes that quasar has a core region analogous to black hole in the sense that the radius is apart from numerical factor near unit $r_S = 2GM$. This comes from mere dimensional analysis.

2.1 Blackholes in TGD framework

In TGD the metric of blackhole exterior makes sense and also part of interior is embeddable but there is not much point to consider TGD counterpart of blackhole interior, which represents failure of GRT as a theory of gravitation: the applicability of GRT ends at r_S. The following picture is an attempt to combine ideas about hierarchy of Planck constant and from the model of solar interior [25] deriving from the 10 year old nuclear physics anomaly [4, 6].

1. The TGD counterpart of blackhole would be maximally dense spaghetti formed from monopole flux tube. Stars would not be so dense spaghettis. A still open challenge is to formulate precise conditions giving the condition $r_S = 2GM$. The fact that condition is "stringy" with $T = 1/2G$ taking formally the role of string tension encourages the spaghetti idea with length of cosmic string/flux tube proportional to r_S.

2. The maximal string tension allowed by TGD is determined by CP_2 radius and estimate for Kähler coupling strength as $1/\alpha_K \simeq 1/137$ and is roughly $T_{max} \sim 10^{-7.5}/G$ suggesting that in blackhole about $10^{7.5}$ parallel flux tubes with maximal string tension and with length of about r_S give rise to blackhole like entity. Kind of dipole core consisting of monopole flux tubes formed by these flux tubes comes in mind. The flux tubes could close to short flux tubes or flux tubes could continue like flux lines of dipole magnetic field and thicken so that the energy density would be reduced.

3. This picture conforms with the proposal that the integer n appearing in effective Planck constant $h_{eff} = n \times h_0$ can be decomposed to a product $n = m \times r$ associated to space-time surface which is m-fold covering of CP_2 and r-fold covering of M^4. For $r = 1$ m-fold covering property could be interpreted as a coherent structure consisting of m almost similar regions projecting to M^4: one

could say that one has field theory in CP_2 with m-valued fields represented by M^4 coordinates. For $r = 1$ each region would correspond to r-valued field in CP_2.

This suggests that Newton's constant corresponds apart from numerical factors $1/G = m\hbar/R^2$, where R is CP_2 radius (the radius of geodesic circle). This gives $m \sim 10^{7.5}$ for gravitational flux tubes. The deviations of m from this value would have interpretation in term of observed deviations of gravitational constant from its nominal value. In the fountain effect of super-fluidity the deviation could be quite large [11].

Smaller values of h_{eff} are assigned in the applications of TGD with the flux tubes mediating other than gravitational interactions, which are screened and should have shorter scale of quantum coherence. Could one identify corresponding Planck constant in terms of the factor r of m: $h_{eff} = r\hbar_0$? TGD leads also to the notion of gravitational Planck constant $\hbar_{gr} = GMm/v_0$ assigned to the flux tubes mediating gravitational interactions - presumably these flux tubes do not carry monopole flux.

4. Length scale dependent cosmological constant should characterize also blackholes and the natural first guess is that the radius of the blackhole corresponds to the scaled defined by the value of cosmological constant. This allows to estimate the thickness of the flux tube by a scaling argument. The cosmological constant of Universe corresponds to length scale $L = 1/\sqrt{\Lambda} \sim 10^{26}$ m and the density ρ of dark energy corresponds to length scale $r = \rho^{-1/4} \sim 10^{-4}$ m. One has $r = (8\pi r)^{1/4}\sqrt{Ll_P}$ giving the scaling law $(r/r_1) = (L/L_1)^{1/2}$. By taking $L_1 = r_s(Sun) = 3$ km one obtains $r_1 = .7 \times 10^{-15}$ m rather near to proton Compton length 1.3×10^{-15} m and even nearer to proton charge radius $.87 \times \times 10^{-15}$ m. This suggests that the nuclei arrange into flux tubes with thickness of order proton size, kind of giant nucleus. Neutron star would be already analogous structure but the flux tubes tangled would not be so dense.

   Denoting the number of protons by N, the length of flux tube would be $L_1 \simeq Nl_p \equiv xr_S$ (l_p denotes proton Compton length) and the mass would be Nm_p. This would give x as $x = (l_p/l_{Pl})^2 \sim 10^{38}$. Note that the ratio of the volume filled by the flux tube to the M^4 volume V_S defined by r_S is

$$\frac{V_{tube}}{V_S} = \frac{3}{8}(\frac{l_P}{l_{Pl}})^2 \times (\frac{l_p}{r_S})^2 \sim 10(\frac{r_S(Sun)}{r_S})^2 \quad . \tag{2.1}$$

   The condition $V_{tube}/V_S < 1$ gives a lower bound to the Schwartschild radius of the object and therefore also to its mass: $r_S > \sqrt{10}r_S(Sun)$ and $M > \sqrt{10}M(Sun)$. The lower bound means that the flux tube fills the entire M^4 volume of blackhole. Blackhole would be a volume filling flux tube with maximal mass density of protons (or rather, neutrons -) per length unit and therefore a natural endpoint of stellar evolution. The known lower limit for the mass of stellar blackhole is few stellar masses (see `http://tinyurl.com/ycd4w4m4`) so that the estimate makes sense.

5. An objection against this picture are very low mass stars with masses below $.5M(Sun)$ (see `http://tinyurl.com/ceoo6sj`) not allowed for $k \geq 107$. They are formed in the burning of hydrogen and the time to reach white dwarf state is longer than the age of the universe. Could one give up the condition that flux tube volume is not larger than the volume of the star. Could one have dark matter in the sense of n_2-sheeted covering over M^4 increasing the flux tube volume by factor n_2.

6. This picture does not exclude star like structure realized in terms of analogs of protons for scaled up variants of hadron physics M_{89} hadron physics would have mass scale scaled up by a factor 512 with respect to standard hadron physcs characterized by Mersenne prime M_{107}. The mass scale would correspond to LHC energy scale and there is evidence for a handful of bumps having interpretation as M_{89} mesons. It is of course quite possible that M_{89} baryons are unstable against transforming to M_{107} baryons.

7. The model for star [25] inspired by the 10 year old nuclear physics anomaly led to the picture that protons form at least in the core dark proton sequences associated with the flux tube and that the scaled up Compton length of proton is rather near to the Compton length of electron: there would be zooming up of proton by a factor about $2^{11} \sim m_p/m_e$. The formation of blackhole would mean reduction of h_{eff} by factor about 2^{-11} making dark protons and neutrons ordinary.

2.2 Can one see also stars as blackhole like entities?

The assignment of blackholes to almost any physical objects is very fashionable, and the universality of the flux tube structures encourages to ask whether the stellar evolution to blackhole as flux tube tangle could involve discrete steps involving blackhole like entities but with larger Planck constant and with larger radius of flux tube.

1. Could one regard stellar objects as blackholes labelled by various values of Planck constant h_{eff}? Note that h_{eff} is determined essentially as the dimension n of the extension of rationals [12, 18]. The possible p-adic length scales would correspond to the ramified primes of the extension. p-Adic length scale hypothesis selects preferred length scales as $p \simeq 2^k$, with prime values of k preferred. Mersennes and Gaussian Mersennes would be in favoured nearest to powers of 2.

   The most general hypothesis is that all values of k in the range $[127, 107]$ are allowed: this would give half-octaves spectrum for p-adc length scales. If only odd values of k are allowed, one obtains octave spectrum.

2. The counterpart of Schwartchild radius would be $r_S(k) = (L(k)/L(107))^2 r_S$ corresponding to the scaling of maximal string tension proportional to $1/G$ by $L(107)/L(k)^2$, where k is consistent with p-adic length scale hypothesis.

   The flux tube area would be scaled up to $L(k)^2 = 2^{k-107}L(107)^2$, and the constant $x \equiv x(107)$ would scale to $x(k) = 2^{k-107}x$. Scaling guarantees that condition $V(tube)/V_S$ does not change at all so that the same lower bound to mass is obtained. Note that the argument do not give upper bound on the mass of star and this conforms with the surprisingly large masses participating in the fusion of blackholes producing gravitational radiation detected at LIGO.

3. The favoured p-adic length scales between p-adic length scale L_{107} assignable to black hole and $L(127)$ corresponding to electron Compton length assignable to solar interior are the p-adic length scale $L(113) = 8L(127)$ assignable to nuclei, and the length scale $L(109)$, which corresponds to p near prime power of two.

   (a) For $k = 109$ (assignable to deuteron) the value of the mass would be scaled by factor 4 to a lower about 12 km to be compared with the typical radius of neutron star about 10 km. The masses of neutron stars around about 1.4 solar masses, which is rather near to the lower bound derived for blackholes. Neutron star could be seen the last phase transition in the sequence of p-adic phase transition leading to the formation of blackhole.

   (b) Could $k = 113$ phase precede neutron stars and perhaps appear as an intermediate step in supernova? Assuming that the flux tubes consist of nucleons (rather than nuclei), one would have $r_S(113) = 64r_S$ giving in the case of Sun $r_S(113) = 192$ km.

   (c) For $k = 127$ the p-adic scaling from $k = 107$ would give Schwartschild radius $r_S(127) \sim 2^{20}r_S$. For Sun this would give $r_S(127) = 3 \times 10^9$ m is roughly by factor 4 larger than the radius of the solar photosphere radius 7×10^8 meters. $k = 125$ gives a correct result. This suggests that $k = 127$ corresponds to the minimal value of temperature for ordinary fusion and corresponds to the value of dark nuclear binding energy at magnetic flux tubes.

   The evolution of stars increases the fraction of heavier elements created by hot fusion and also temperatures are higher for stars of later generations. This would suggest that the value of

k is gradually reduced in stellar evolution and temperature increases as $T \propto 2^{(127-k)/2}$. Sun would be in the second or third step as far the evolution of temperature is considered. Note that the lower bound on radius of star allows also larger radii so that the allowance of smaller values of k does not lead to problems.

2.3 What about blackhole thermodynamics?

Blackhole thermodynamics is part of the standard blackhole paradigm? What is the fate of this part of theoretical physics in light of the proposed model?

Consider first the natural picture implied the vision about blackhole as space-filling flux tube tangle.

1. The flux tubes are deformations of cosmic strings characterized by cosmological constant which increases in the sequence of increasing the temperature of stellar core. The vibrational degrees of freedom are excited and characterized by a temperature. The large number of these degrees of freedom suggests the existence of maximal temperature known as Hagedorn temperature at which heat capacity approaches to infinity value so that the pumping of energy does not increase temperature anymore.

   The straightforward dimensionally motivated guess for the Hagedorn temperature is suggested by p-adic length scale hypothesis as $T = x\hbar/L(k)$, where x is a numerical factor. For blackholes as $k = 107$ objects this would give temperature of order 224 MeV for $x = 1$. Hadron physics giving experimentally evidence for Hagedorn temperature about $T = 140$ MeV near to pion mass and near to the scale determined by Λ_{QCD}, which would be naturally relate to the hadronic value of the cosmological constant Λ.

   The actual temperature could of course be lower than Hagedorn temperature and it is natural to imagine that blackhole cools down. The Hagedorn temperature and also actual temperature would increase in the phase transition $k \to k - 1$ increasing the value of $\Lambda(k)$ by a factor of 2.

2. The overall view about the situation would be that the thermal excitations of cosmic string die out by emissions assignable perhaps to black hole jets and also going to the cosmic string until a state function reduction decreasing the value of k occurs and the process repeats itself.

   The naive idea is that this process eventually leads to ideal cosmic string having Hagedorn temperature $T = \hbar/R$ and possible existing at very low temperature: this would conform with the idea that the process is the time reversal of the evolution leading from cosmic strings to astrophysical objects as tangles of flux tube. This would at least require a phase transition replacing M_{107} hadron physics with M_{89} hadron physics and this with subsequent hadron physics. One must of course consider also all values of k as possible options as in the case of the evolution of star. The hadron physics assignable to Mersenne primes and their Gaussian counterparts could only be especially stable against a phase transition increasing $\Lambda(k)$.

2.3.1 What happens to blackhole thermodynamics in TGD?

Blackhole thermodynamics (see `http://tinyurl.com/y7pvj23x`) has produced admirable amounts of literature during years. What is the fate of the blackhole thermodynamics in this framework? It turns out that the the dark counterpart of of Hawking radiation makes sense if one accepts the notion of gravitational Planck constant assigned to gravitational flux tube and depending on masses assignable to the flux tube. The condition that dark Hawking radiation and flux tubes at Hagedorn temperature are in thermal radiation implying $T_{B,dark} = T_H$. The emerging prediction T_H is consistent with the value of the hadronic Hagedorn temperature.

1. In standard blackhole thermodynamics the blackhole temperature T_B identifiable identifiable as the temperature of Hawking radiation (see `http://tinyurl.com/md6mmvg`) is essentially the surface

gravity at horizon and equal to $T_B = \kappa/2\pi = \hbar/4\pi r_S$ is analogous to Hagedorn temperature as far as dimensional analysis is considered. One could think of assigning T_B to the radial pulsations of blackhole like object but it is very difficult to understand how the thermal isolation between stringy degrees of freedom and radial oscillation degrees of freedom could be possible.

2. The ratio $T_B/T_H \sim L_p/4\pi r_S$ would be extremely small for ordinary value of Planck constant. Situation however changes if one has

$$T_B = \frac{\hbar_{eff}}{4\pi r_S} \ , \tag{2.2}$$

with $\hbar_{eff} = n\hbar_0 = \hbar_{gr}$, where $\hbar_{gr}$ is gravitational Planck constant.

The gravitational Planck constant $\hbar_{gr}$ was originally introduced by Nottale [1] [10, 9] assignable to gravitational flux tube (presumably non-monopole flux tube) connecting dark mass M_D and mass m (M and m touch the flux tubes but do not define its ends as assumed originally) is given by

$$\hbar_{gr} = \frac{GM_D m}{v_0} \ , \tag{2.3}$$

where $v_0 < c$ is velocity parameter. For the Bohr orbit model of inner planets Nottale assumes $M_D = M(Sun)$ and $\beta_0 = v_0/c \simeq 2^{-11}$. For blackholes one expects that one has $\beta_0 < 1$ is not too far from $\beta_0 = 1$.

The identification of M_D is not quite clear. I have considered the problem how v_0 and M_D are determined in [20, 19] [14]. For the inner planets of Sun one would have $\beta_0 \sim 2^{-11} \sim m_e/m_p$. Note that the size of dark proton would be that of electron, and one could perhaps interpret $1/\beta_0$ as the $h_{eff}/\hbar$ assignable to dark protons in Sun. This would solve the long standing problem about identification of β_0.

3. One would obtain for the Hawking temperature $T_{B,D}$ of dark Hawking radiation with $h_{eff} = h_{gr}$

$$T_{B,D} = \frac{\hbar_{gr}}{\hbar} T_B = \frac{1}{8\pi\beta_0} \times \frac{M_D}{M} \times m \ . \tag{2.4}$$

For $k = 107$ blackhole one obtains

$$\frac{T_{B,D}}{T_H} = \frac{\hbar_{gr}}{\hbar} \times T_B \times \frac{L(107)}{x\hbar} = \frac{1}{8\pi\beta_0(107)} \times \frac{M_D}{M} \times \frac{L(107)m}{x\hbar} \ . \tag{2.5}$$

For $m = m_p$ this gives

$$\frac{T_{B,D}}{T_H} = \frac{\hbar_{gr}}{\hbar} T_B \times \frac{L(107)}{x\hbar} = \frac{1}{8\pi x\beta_0(107)} \times \frac{M_D}{M} \times \frac{m_p}{224 \ MeV} \ . \tag{2.6}$$

The order of magnitude of thermal energy is determined by m_p. The thermal energy of dark Hawking photon would depend on m only and would be gigantic as compared to that of ordinary Hawking photon.

4. Thermal equilibrium between flux tubes and dark Hawking radiation looks very natural physically. This would give

$$\frac{T_{B,D}}{T_H} = 1 \tag{2.7}$$

giving the constraint

$$\frac{\hbar_{gr}}{\hbar} T_B \times \frac{L(107)}{x\hbar} = \frac{1}{8\pi x\beta_0} \times \frac{M_D}{M} \frac{m_p}{224\ MeV} = 1 \ . \tag{2.8}$$

on the parameters. For $M/M_D = 1$ this would give $x\beta_0 \simeq 1/6.0$ conforming with the expectation that β_0 is not far from its upper limit.

5. If ordinary stars are regarded as blackholes in the proposed sense, one can assign dark Hawking radiation also with them. The temperature is scaled down by $L(107)/L(k)$ and for Sun this would give factor of $L(107)/L(125) = 2^{-9}$ if one requires that $r_S(k)$ corresponds to solar radius. This would give

$$T_B(dark, k) \to \frac{\hbar_{gr}}{\hbar} \times \frac{L(107)}{L(k)} T_B = \frac{2^{(k-107)/2}}{8\pi\beta_0} \times \frac{M_D}{M} \times m \ . \tag{2.9}$$

For $k = 125$ and $M_D = M$ this would give $T_B(dark, 125) = m/2\pi$.

The condition $T_{B,D} = T_H$ for $k = 125$ would require scaling of $\beta_0(107)$ to $\beta(125) = 2^{-9}\beta_0(107) \simeq 2^{-11}$. This would give $\beta_0(107) \simeq 1/4$ in turn giving $x \simeq .66$ implying $T_H \simeq 149$ MeV. The replacement of $m_p = 1$ GeV with correct value $m_p = .94$ GeV improves the value. This value is consistent with the value of hadronic Hagedorn temperature so that there is remarkable internal consistency involved although a detailed understanding is lacking.

6. The flux of ordinary Hawking thermal radiation is $T_B^4/\hbar^3$. The flux of dark Hawking photons would be $T_{B,dark}^4/\hbar_{gr}^3 = (\hbar_{gr}/\hbar)T_B^4$ and therefore extremely low also now also. In principle however the huge energies of the dark Hawking quanta might make them detectable. I have already earlier proposed that $T_B(h_{gr})$ could be assigned with gravitational flux tubes so that thermal radiation from blackhole would make sense as dark thermal radiation having much higher energies.

One can however imagine a radical re-interpretation. BHE is not the thermal object emitting thermal radiation but BHE plus gravitational flux tubes are the object carrying thermal radiation at temperature $T_H = T_B$. For this option dark Hawking radiation could play fundamental role in quantum biology as will be found.

7. What about the analog of blackhole entropy given by

$$S_B = \frac{A}{4G} = \pi \frac{l_{Pl}^2}{T_B^2} \ , \tag{2.10}$$

where $A = 4\pi r_S^2$ is blackhole surface area. This corresponds intuitively to the holography inspired idea that horizon decomposes to bits with area of order l_P^2?

The flux tube picture does not support this view. One however ask whether the volume filling property of flux tube could effectively freeze the vibrational degrees of flux tubes. Or whether these degrees of freedom are thermally frozen for ideal blackhole. If so, only the ends of he flux tubes at the surface or their turning points (in case that they are turn back) can oscillate radially. This would give an entropy proportional to the area of the surface but using flux tube transversal area as a unit. This would give apart from numerical constant

$$S_B = \frac{A}{4L(k)^2} \quad . \tag{2.11}$$

2.3.2 Constraint from $\hbar_{gr}/\hbar > 1$

What values of mass m can interact quantum gravitationally and are thus allowed in h_{gr} for given M_D?

1. The notion of h_{gr} makes sense only for $h_{gr} > h$. If one has $h_{gr} < h$ assume $h_{gr} = h$. An alternative would be $h_{gr} =\rightarrow h_0 = h/6$ for $h_{gr} < h_0$. This would given $GM_Dm/v_0 > \hbar_{min}$ ($\hbar_{min} = \hbar$ or $\hbar/6$) leading

$$m > \frac{\beta_0\hbar}{2r_S(M_D)} \times \frac{\hbar_{min}}{\hbar} \quad . \tag{2.12}$$

   This condition is satisfied in the case of stellar blackholes for all elementary particles.

2. One can strengthen this condition so that it would satisfied also for gravitational interactions of two particles with the same mass ($M_D = m$). This would give

$$\frac{m}{m_{Pl}} > \sqrt{\beta_0} \quad . \tag{2.13}$$

   For $\beta_0 = 1$ this would give $m = m_{Pl}$, which corresponds to a mass scale of a large neuron and to size scale 10^{-4} m. $\beta_0(125) = 2^{-11}$ gives mass scale of cell and size scale about 10^{-5} meters. $\beta_0(127) \simeq 2^{-12}$ corresponding to minimum temperature making hot fusion possible gives length scale about 10^{-6} m of cell nucleus. A possible interpretation is that the structure in cellular length scale have quantum gravitational interaction via gravitational flux tubes. Biological length scales would be raised in special position from the point of view of quantum gravitation.

3. Also interactions of structures smaller than the size of cell nucleus with structures with size larger the size of cell nucleus are possible. By writing the above condition as $(m/m_{Pl})(M_D/m_{pl}) > \beta_0$, one sees that from a given solution to the condition one obtains solutions by scaling $m \rightarrow xm$ and $M_D \rightarrow M_D/x$. For $\beta_0(127) \simeq 2^{-11}$ corresponding to the scale of cell nucleus the atomic length scale 10^{-10} m and length scale 10^{-4} m of large neuron would correspond to each other as "mirror" length scales. There would be no quantum gravitational interactions between structures smaller than cell nucleus. There would be master-slave relationship: the smaller the scale of slave, the larger the scale of the master.

2.3.3 Quantum biology and dark Hawking radiation

The scaling formula $\beta_0(k) \propto 1/L(k)$ with flux tube thickness scale given by $L(k)$ allows to estimate $\beta_0(k)$. In this manner one obtains also biologically interesting length scales. An interesting question is whether the scales for the velocities of Ca waves (see `http://tinyurl.com/qs3j5cp`) and nerve pulse conduction velocity could relate to v_0.

1. The tube thickness about 10^{-4} m, which corresponds to ordinary cosmological constant being in this sense maximal corresponds to the p-adic length scale $k = 171$. The scaling of $\beta_0 \propto 1/L(k)$ gives $v_0(171) \sim 4.7$ μm/s In eggs the velocity of Ca waves varies in the range 5-14 μm/s, which roughly corresponds to range $k \in \{171, 170, 169, 168\}$.

   In other cells Ca wave velocity varies in the range 15-40 μm/s. $k = 165$ corresponds to 37.7 μm/s near the upper bound 40 μm/s. The lower bound corresponds to $k = 168$. $k = 167$, which corresponds to the larges Gaussian Mersenne in the series assignable to $k \in \{151, 157, 163, 167\}$ the velocity is 75 μm/s.

2. For $k = 127$ gives $v_0 \sim 75$ m/s. $k = 131$ corresponds to $v_0 = 18$ m/s. These velocities could correspond to conduction velocities for nerve pulses in accordance with the view that the smaller the slave, the larger the master.

I have already earlier considered that dark Hawking radiation could have important role in living matter. The Hawking/Hagedorn temperature assuming $x = 1/6.0$ $k = L(171)$ has peak energy 38 meV to be compared with the membrane potential varying in the range 40-80 meV. Room temperature corresponds to 34 meV. For $k = 163$ defining Gaussian Mersenne one would have peak energy about .6 eV: the nominal value of metabolic energy quantum is .5 eV. $k = 167$ corresponds to .15 eV and 8.6 μm - cell size. Even dark photons proposed to give bio-photons when transforming to ordinary photons could be seen as dark Hawking radiation: Gaussian Mersenne $k = 157$ corresponds to 4.8 eV in UV. Could CMB having peak energy of .66 meV and peak wavelength of 1 mm correspond to Hawking radiation associated with $k = 183$? Interestingly, cortex contains 1 mm size structures.

To sum up, these considerations suggest that biological length scales defined by flux tube thickness and cosmological length scales defined by cosmological constant are related.

2.4 Zero energy ontology, cosmology, and astrophysics

Zero energy ontology replaces ordinary ontology in TGD based view about quantum states and quantum jump [26].

1. In ZEO zero energy states are superpositions of space-time surfaces inside causal diamond (CD) identified as preferred extremals of the basic action principle of TGD. CD is cartesian product of causal diamond cd of M^4 and of CP_2. The preferred extremals analogous to Bohr orbits have boundaries - ends of space-time - at the light-like boundaries of CD. There is a fractal hierarchy of CDs and given CD is an imbedding space correlate for a conscious entity - self - consciousness is universal.

2. Zero energy states can be seen as superpositions of state pairs with members assigned to the opposite boundaries of CD. ZEO predicts that in ordinary or "big" state function reductions (BSFRs) the arrow of time of system changes and remains unaffected in "small" state functions (SSFRs), which are TGD counterpart for "weak" measurements and associated with a sequence of unitary evolution for the state assignable to the active boundary CD, which also shifts farther from the passive boundary. Passive boundary is unaffected as also members of state pairs at it.

3. Subjective time is identified as a sequence of SSFRs and correlates strongly with clock time identifiable as the distance between the tips of CD and increasing in statistical sense during the sequences of SSFRs.

4. BSFR corresponds to state function reduction at active boundary of CD which becomes passive. This forces the state at passive boundary to change. Passive boundary becomes active. BSFR means the death of self and reincarnation with an opposite arrow of time. Thus the notion of life cycle is universal and life can be lieved in both directions.

5. What happens to CD in long run? There are two options.

   (a) The original assumption was that the location of formerly passive boundary is not changed. This would mean that the size of CD would increase steadily and the outcome would be eventually cosmology: this sounds counter-intuitive. Classically energy and other Poincare charges are conserved for single preferred extremal could fail in BSFRs due to the fact that zero energy states cannot be energy eigenstates.

   (b) The alternative view suggested strongly $M^8 - H$ duality [12] is that the size of CD is reduced in BSFR so that the new active boundary can be rather near to the new passive boundary. One could say that the reincarnated self experiences childhood. In this case the size of CD can remain finite and its location in M^8 more or less fixed. One can say that the self associated with the CD is in a kind of Karma's cycle living its life again and again. Since the extension of rationals can change in BSFR and since the number of extensions larger than given extension is infinitely larger than those smaller than it, the dimension of extension identifiable in terms of effective Planck constant increases. Since $n = h_{eff}/h_0$ serves as a kind of IQ, one can say that the system becomes more intelligent.

2.4.1 Cosmic redshift but no expansion of receding objects: one further piece of evidence for TGD cosmology

Universe is Not Expanding After All, Controversial Study Suggests was the title of very interesting Science News article (see `http://tinyurl.com/o6vyb9g`) telling about study, which forces to challenge Big Bang cosmology. The title of course involved the typical exaggeration.

The idea behind the study was simple. If Universe expands and also astrophysical objects - such as stars and galaxies - participate the expansion, they should increase in size. The observation was that this does not happen! One however observes the cosmic redshift so that it is too early to start to bury Big Bang cosmology. This finding is however a strong objection against the strongest version of expanding Universe. That objects like stars do not participate the expansion was actually known already when I developed TGD inspired cosmology for quarter century ago, and the question is whether GRT based cosmology can model this fact naturally or not.

The finding supports TGD cosmology based on many-sheeted space-time. Individual space-time sheets do not expand continuously. They can however expand in jerk-wise manner via quantum phase transitions increasing the p-adic prime characterizing space-time sheet of object by say factor two of increasing the value of $h_{eff} = n \times h$ for it. This phase transition could change the properties of the object dramatically. If the object and suddenly expanded variant of it are not regarded as states of the same object, one would conclude that that astrophysical objects do not expand but only comove. The sudden expansions should be observable and happen also for Earth. I have proposed a TGD variant of Expanding Earth hypothesis along these lines [21].

2.4.2 Stars as reincarnating conscious entities?

One can apply ZEO to the evolution of stars. The basic story (see `http://tinyurl.com/ceoo6sj`) is that the star is formed from he interstellar gas cloud, evolves and eventually collapses to a white dwarf, degenerate carbon-oxygen core, supernova or even blackhole if the mass of the remnant resulting in explosion throwing outer layers of the star away is in the range of 3-4 solar masses. Only very massive stars end up to supernovas. The type of the star depends on the abundances of various elements in the interstellar gas from which they formed and believed to contain heavier elements produced by earlier supernovas.

There are however several anomalies challenging the standard story. There are stars older than Universe (see `http://tinyurl.com/s698l86`). There is also evidence that the abundances of heavier

elements in the early cosmology are essentially the same as for modern stars [3] (see `http://tinyurl.com/qkk26dv`). TGD based explanation is discussed in [25].

Karma's cycle option for the stellar evolution could explain these anomalies.

1. Stars would be selves in Karma's cycle with their magnetic bodies reincarnating with a reversed arrow of time in a collapse to blackhole/white hole like entity (BHE/WHE) - depending on the arrow of time. This would follow by a stellar evolution leading to an asymptotic state BHE/WHE corresponding to maximum size of CD followed by a collapse to BHE or WHE. Also ordinary stars would correspond to BHEs/WHEs characterized by p-adic length scale $L(k)$ longer than $L(107)$ assignable to GRT blackholes. In standard time direction WHE would look like blackhole evaporation.

2. This would allow stars older than the Universe and suggests also universal abundances. Note however that the abundances would strongly depend on the abundances of the interstellar gas and matter produced by the magnetic energy of flux tube. "Cold fusion" as dark fusion could produce elements heavier than Fe and light elements Li, Be, B, whose abundances for fusion in stellar core is predicted to be much much smaller than the observed abundances in the case of old stars. The lifetimes of stars depend on their type. Also a universal age distribution of stars in stellar clusters not depending appreciably on cosmic time is highly suggestive. I remember of even writing about this. Unfortunately I could not find the article.

To put it more generally, the hierarchy of CDs implies that the Universe decomposes effectively to sub-Universes behaving to some degree independently. The view about Karma's cycles provides a more precise formulation of the pre-ZEO idea that systems are artists building themselves as 4-D sculptures. In particular, this applies to mental images in TGD based view about brain.

1. One could perhaps say that also quantum non-determinism has classical correlates. CDs would be the units for which time-reversing BSFRs are possible. Also SSFRs affecting CDs could have classical space-time correlates. $M^8 - H$ duality [12] predicts that the time evolution for space-time surface inside CDs decomposes to a sequence of deterministic evolutions glued together along M^4 time $t = r_n$ hyperplanes of M^4 defining special moments in the life of self at which the new larger CD receives a new root $t = r_n$. The non-deterministic discontinuity could be localized to the 2-D vertices represented by partonic 2-surfaces at which the ends of light-like partonic orbits meet.

2. The M^4 hyperplanes $t = r_n$ correspond to the roots of a real polynomial with rational coefficients defining the space-time surfaces at the level of M^8 as roots for the real or imaginary part in quaternionic sense for the octonionic continuation of the polynomial. These moments of time could correspond to SSFRs.

3. The finite classical non-determinism is in accordance with the classical non-determinism is predicted at the limit of infinitely large CD and vanishing cosmological constant at which classical action reduces to Kähler action having a huge vacuum degeneracy due to the fact than any space-time surface having Lagrangian manifold (vanishing induced Kähler form) as CP_2 projection is a vacuum extremal. The interpretation of this degeneracy interpreted in terms of 4-D spin glass degeneracy would be that at the limit of infinitely large CD the extension of rationals approaches to algebraic numbers and the roots $t = r_n$ becomes dense and the dynamics becomes non-deterministic for vacuum extremals and implies non-determinism for non-vacuum extremals.

2.4.3 No time dilation for the periods of processes of quasars

There are strange findings about the time dilation of quasar dynamics challenging the standard cosmology [7]. One expects that the farther the object is the slower its dynamics looks as seen from Earth. Lorentz invariance implies red shift for frequencies and in time domain this means the stretching of time intervals so that the evolution of distant objects should look the slower the longer their distance from the observer

is. In the case of supernovae this seems to be the case. What was studied now were quasars at distances of 6 and 10 billion years and the time span of the study was 28 years [8]. Their light was red shifted by different amounts as one might expect but their evolution went on exactly the same rhythm. This looks really strange.

In GRT the redshift violates conservation of four-momentum. In TGD cosmic redshift reduces to the fact that the tangent spaces of the space-time surface for target and receiver differ by a Lorentz boost. Redshift does not mean non-conservation of four-momentum but only that the reference frames are different for target and observer. The size for the space-time sheets assignable to the systems considere must be large, of the order of the size scale L defined by the size of the recent cosmology to which one assigns the Hubble constant. In the flux tube picture this means that the flux tubes have length of order L but thickness would be about $R = 10^{-4}$ meters - the size scale of large neuron. Photons arrive along flux tubes connecting distant systems. Note that CMB corresponds to 10 times longer peak wavelength.

I have already earlier discussed this time anomaly [13] but what I have written is just the statement of the problem and and some speculations about its solution in terms of ZEO. A valuable hint is that the time anomaly appears for quasars- very heavy objects - but not for supernovae - much lighter objects. This suggests that the redshift depends on the masses of the objects considered.

1. One considers an approximately periodic process. It is quite possible that this process is not classical deterministic process at space-time level but that one has sequence of SSFRs (weak measurements) or even BSFRs for a subsystem of the target. These processes replace quantum superposition of space-time surfaces inside CD with a new one and SSFR also increases its size in statistical sense. A natural Lorentz invariant "clock time" for the target is the distance between the tips of CD - light-cone proper time. Both M^4 linear coordinates and light-cone Robertson-Walker coordinates are natural coordinates for space-time sheets with 4-D M^4 projection.

   "Clock time" must be mapped to M^4 linear time for some space-time sheet. The Minkowski coordinates for the CD are determined only modulo Lorentz boost leaving the light-like boundary of CD invariant. In general the M^4 coordinates of the target and observer are related by a Lorentz boost and this gives rise to cosmological redshift and also gravitational reshift.

2. The information about SSFR or BSFR at the target must be communicated to the observer so that the space-time sheets in question must be connected by flux tubes carrying the photons. CD must contain both systems and naturally has cosmological size given by L so that flux tubes have thickness about R. The M^4 time coordinate must be common to both systems. The natural system to consider is center of mass system (cm) in which the sum of the momenta of two systems vanishes.

2.4.4 Did cosmology have any "Dark Ages"?

A further potential time anomaly of the recent cosmology relates to theDark Agesof the Universe. Between the decoupling of CMB radiation from matter and the formation of stars there should have been aDark Agesduring which there was only neutral hydrogen. Star formation generated radiation at energies high enough to ionize hydrogen and the ionized interstellar gas started to produce radiation.

The 21 cm line of neutral hydrogen serves as a signature of neutral hydrogen. This line is redshifted and from the lower bound for the redshift one can deduce the time when "Dark Ages" ended. The popular article tells (see `http://tinyurl.com/wzegzxk`) that the recent study using Murchison Widefield Array (MWA) radio telescope by Jonathan Pober and collaborators gave an unexpected result. Only a new lower upper bound for this redshift emerged: the upper bound corresponds to about 2 meters [5] (see `http://tinyurl.com/qttq3gl`). The conclusion of the experimenters is optimistic: soon the upper bound for the redshift should be brought to light.

In TGD based view about cosmology and astrophysics (`http://tinyurl.com/tkkyyd2`) one can formulate two questions.

1. One can ask whether there were any "Dark Ages" at all!

2. An alternative question is whether the "Dark Ages" in distant geometric past are prevailing anymore! This would be like asking whether the Hitler of thirties is the Hitler we know anymore. The point is that in TGD framework one must distinguish between subjective time and geometric time and this leads to some rather dramatic modifications of the prevailing view about time. The following arguments encourage a positive answer to the first question and negative answer to the second question.

The following arguments encourage positive answer to the first question and negative answer to the second question.

The answer to the first question relies of TGD based view about nuclear physics solving anomalies of standard nuclear physics and leading to a new view about stellar evolution.

1. In TGD framework the formation of stars could have preceded by a pre-stellar period during which dark fusion giving rise to dark proton sequences - dark nuclei - at monopole flux tubes happened: this is Pollack effect in biology. This would have been "cold fusion" period in the stellar evolution and would have occurred spontaneously at low temperatures. It would have already produced abundances, which are not far from modern ones and one of the recent surprises is that the abundances at very early period are already near to modern ones.

2. The model predicts also the possibility of neutral states for which electrons are at flux tubes parallel to dark proton flux tubes and have the same scaled up size (due to non-standard value of $h_{eff} = nh_0$, which is smaller by factor about 1/2000) as dark protons. In solar interior dark protons would have Compton size of electron so that h_{eff} for them would be about 2000 times higher $H = M^4 \times CP_2$ than h. Also smaller and larger value of h_{eff} are possible. For blackholes the protons at flux tubes would be ordinary: $h_{eff} = h$.

3. The transformation of dark nuclei having much smaller binding energy would have liberated nuclear binding energy and the resulting photons having energy up to gamma ray energies would have ionized the neutral hydrogen.

Zero energy ontology (ZEO) leads to a negative answer to the question whetherDark Ages still prevail in distant past.

1. In ZEO Universe consists at the level of imbedding space $H = M^4 \times CP_2$ of a fractal hierarchy of $CD = cd \times CP_2$, where cd is causal diamond of M^4. CDs have interpretation as a hierarchy of sub-cosmologies. Each CD defines a correlate for a conscious entity and increases in size in each "small" state function reduction (SSFR) defining a counterpart of weak measurement. The flow of experienced time corresponds to the increase of distance between tips of CD. Second boundary of CD is however fixed - passive - as also members of state pairs at it defining zero energy states. The active boundary recedes farther away from the passive one. This gives rise to the arrow of time for given life of CD.

2. In a "big" (ordinary) state function reduction (BSFR) the roles of boundaries of CD change. Active becomes passive and vice versa. The arrow of time changes. Self dies and reincarnates with opposite arrow of time. The simplest possibility is that the size of CD can decrease in BSFR meaning that the formerly passive boundary becomes much nearer to active. In this case CD begins to grow from a small size: self has "childhood". In this case it can happen that self never reaches a size larger than some upper bound and lives again and its life. Each life is more evolved since the extension of rationals involved with space-time surface increases in statistical sense in BSFR. This is nothing but Karma's cycle but in all scales.

3. At the level of stars this would mean that star could undergo evolution as Karma's cycle also in cosmological remote past as an object located at fixed point of H. The abundances would be more or

less the same as for modern stars. This would explain the mystery of stars older than the Universe and solve also other time anomalies of the standard cosmology. This explanation is consistent with the first one and actually the first one is needed to explain abundances of nuclei heavier than Fe and the light nuclei Li, B, Be much higher than predicted by standard model. Thus both questions would have positive answer.

2.4.5 Observation of a time reversal of a blackhole like object?

A very strange object behaving like time reversal of blackhole has been observed (`http://tinyurl.com/umzxaoe`). Usually blackhole eat the surrounding matter and also prevent the formation of stars since they are powerful emitters of gamma rays - this is not in accordance with the naive view about blackholes. The weird blackhole does not emit gamma rays and the environment around it cools and this makes possible star formation. Instead of eating the surrounding matter it should feed matter to surroundings making possible the star formation.

The most obvious TGD identification of the mystery object relies on zero energy ontology allowing both arrow of time. The arrow of time chances in ordinary state function reduction - the "big" one as opposed to "small" one corresponding to weak measurement. This predicts time reversed blackhole like objects (BHEs) analogous to white holes: white hole like objects (WHEs).

WHEs could appear in the very early states of the galactic evolution. They could feed the magnetic energy of monopole flux tubes to environment transformed to ordinary matter in turn forming galaxies. As a matter of fact, monopole flux tubes portions emanating it much lines of magnetic field would be formed and their local thickening and formation of tangles would give rise to stars.

If the time reversal idea is taken very seriously WHEs should suck gamma rays from environment inducing cooling making the star formation easier. This would be dissipation in non-standard direction of time identifiable as the basic metabolic mechanism associated with all kinds of self-organization process: quantum coherence at the level of magnetic body would be essential and induce long range coherence of ordinary matter as forced coherence.

WHE could be also created in BSFR for a BHE.

2.4.6 Do quasars and galactic blackholes relate by time reversal in ZEO?

This picture combined with zero energy ontology (ZEO) based view about ordinary state functions changing the arrow of time and occurring even in astrophysical scales leads to a tentative view about quasars and galactic blackholes as time reversals of each other.

1. Quasars could be seen as analogs of white holes feeding the mass of cosmic string out to build the galactic tangle and part of the mass of thickening tangle would transform to ordinary matter. They would initiate the formation of galaxy meaning emergence of increasing values of h_{eff} in the hierarchy of Planck constant. Cosmic string would basically feed the mass and energy liberated in the decay of magnetic energy at cosmic strings thickening to flux tubes to ordinary matter and serving in the role of metabolic energy driving self-organization.

2. Galactic blackholes could be perhaps indeed analogs of blackholes as time reversals of quasars - "big" (ordinary) state function reduction would transform quasar as white hole to a galactic blackhole. Now the system would be drawing back the mass from the surroundings to the flux tube and maybe cosmic string. The process could be like breathing. In zero energy ontology breathing could indeed involve a sequence of states and their time reversals.

This raises also the question whether the evolution of stars could be seen as a time reverse for the formation of blackholes: kind of growth followed by a decay perhaps since the values of Planck constant h_{eff} would be reduced. The climax of his evolution would correspond to maximal values of h_{eff}. The evolution of life would be certainly this kind of climax.

2.5 Objections against GRT blackholes

The basic theoretical objection against blackholes was due to Einstein himself. The collapse of matter to single point is simply impossible. This objection has been however forgotten since doing calculations is much more pleasant activity than hard thinking, and an enormous literature have been produced based on this idealization. There is no doubt that blackhole like entities (BHEs) with about Schwartschild radius exist, but general relativity does not allow to say anything about the situation inside possibly existing horizon.

2.6 Badly behaving blackholes

There is an excellent video (thanks to Howard Lipman for a link) challenging the standard view about blackholes. In the sequel list some arguments that I remember.

TGD was born as a solution to the fundamental difficulty of GRT due to the loss of classical conservation laws. In TGD framework BHEs correspond to *volume filling* flux tube tangles. Also galactic BHEs would correspond to a volume filling flux tube tangles.

In TGD framework also stars could be seen as BHEs having the flux tube thickness characterized by p-adic length scale as an additional parameter. GRT blackholes correspond to flux tube thickness about proton Compton length. For instance, Sun can be seen as a BHE and the size is predicted correctly.

The model for BHEs makes large number of correct predictions.

1. The minimal radii/masses of GRT blackholes and neutron stars are predicted correctly.

2. Ordinary blackhole thermodynamics is replaced with the thermodynamics associated with monopole flux tubes carrying galactic dark mass characterized by Hagedorn temperature and the thermodynamics gravitational flux tubes characterized by Hawking temperature but for gravitational Planck constant h_{gr} so that it is gigantic as compared to the ordinary Hawking temperature.

   In thermal equilibrium these temperatures are same and this predicts hadronic string tension correctly.

Consider now the empirical objections against BH paradigm in light of TGD picture.

1. The observations by ALMA telescope show that stars can be formed surprisingly near to galactic BHEs (see `http://tinyurl.com/ry746pg`). For instance, 11 young stars just forming have been found at distance of 3 ly from galactic BHE of Milky Way. This is impossible since the intense tidal forces and UV and X ray radiation should make impossible the condensation of stars from gas clouds.

   TGD explanation: Galaxies are formed as tangles on long thickened cosmic string responsible for galactic dark matter as dark energy. Same mechanism give rise to stars as sub-tangles generating at least part of the ordinary matter as decay of the magnetic energy of the flux tube as it thickens. Ordinary matter already present could concentrate around the tangle.

   One learns from the discussion in the above link that star formation involves bipolar flow consisting two jets in opposite directions believed to take care of angular momentum conservation: the star formed is thought to be formed from a rotating gas cloud (rotation would be around flux tube) having much larger angular momentum and part of must be carried out by jets naturally parallel to the flux tube. Also this gives support for the view that stars are tangles along flux tube. There are also hundreds of massive and much older stars in the vicinity of galactic BHE.

   Note that in TGD also these stars could be seen as BHEs but with different p-adic length scale characterizing the thickened flux tube. The reason why galactic BHE does not swallow these objects could be that they are bound states around flux tube (or even cosmic string outside the star), which is rather rigid by its string tension.

2. "Non-hungry" BHEs are found.

   TGD explanation: In zero energy ontology to which quantum TGD relies, one must distinguish between BHEs and their time reversals, white hole like objects (WHEs), analogous to white holes. WHEs would not be "hungry" but feed matter into environment. The counterparts or jets would flow into WHE and matter would flow out from WHE.

3. The standard theoretical belief is that in a dense star cluster only single blackhole can exist. If there are several blackholes, they start to rotate around each other and fuse to a larger blackhole. A case with two blackholes have been however observed.

   TGD explanation: A possible explanation is that the objets are WHEs and their behavior is time reversal of BHEs.

4. The velocities of particles in the jets associated with a galactic BHEs are near light velocity and require extremely high energies and thus strong magnetic fields. No strong magnetic field has been however observed.

   TGD explanation: In TGD Maxwellian magnetic fields are replaced with flux tubes carrying quantized monopole flux not possible in Maxwellian world. Their existence allows to understand the presence of magnetic fields in even cosmological scales, the maintenance problem of Earth's magnetic field, and the recent findings about the magnetic field of Mars [24]. Ordinary magnetic fields correspond to vanishing total flux and are indeed weak: it is these magnetic fields outside the jet which would have been measured. Galaxies are tangles in monopole flux tube and this is the carrier of very strong magnetic field associated with jets parallel to the flux tube.

5. Very distant galactic blackholes with distances in scale of million light years have radio jets in the same direction. This is very difficult to understand in the standard view about cosmology.

   TGD explanation: The galactic BHEs would be associated with the same long cosmic string forming galaxies as tangles.

2.6.1 Too heavy blackhole in Milky Way

The standard model for blackhole formation predicts an upper bound on the mass of blackhole depending also on environment since the available amount of matter in environment is bounded. In the case of Milky Way the bound is about 20 solar masses. Now however a blackhole like entity (BHE) with mass about 70 solar masses has been discovered (see `http://tinyurl.com/w7xlb78`). I am grateful for Wes Johnson for the link. Also the masses of BHEs producing the gravitational radiation in their fusion have been also unexpectedly high, which suggets that standard view about BHEs is not quite correct.

The proposed model for BHEs as a volume filling flux tube gives correct lower bounds for masses of neutron star and TGD counterpart of blackhole but does not give upper bound for the mass. For time reversed BHEs - analogs of white holes (WHEs) possibly identifiable as quasars - the mass of WHE comes from a tangling long cosmic string and there is no obvious upper bound. Even galactic BHEs could correspond to WHEs, which have made quantum jump to BHEs at the level of magnetic body: in this state the flux tube forming the counterpart of Maxwellian magnetic field is fed back from environment. A breathing spaghetti would be in question.

In standard model the mechanism for the formation of blackhole is different since there is no flux tube giving the dominant dark energy/dark matter contribution to the mass. Therefore the upper bound for mass - if there exists such - is expected to increase. In TGD framework the dominant contribution would come from the monopole flux tubes giving rise TGD counterpart of magnetic field which extends at least over the region containing stars assumed to correspond sub-tangles of the galactic flux tangle. Intuitively it seems clear that the upper bound is higher than in GRT. If the spaghetti straightens - the tangled flux tube would untangle - one could have upper bound.

The simplest model predicts that only the flux tube mass contributes to the mass of BHE. The mass of the ordinary matter going to BHE would transform back to dark energy/mass of the flux tube. The process would be time reversal of the process making sense in zero energy ontology [26] in which the magnetic energy of flux tube transforms to ordinary matter: time reversal for the TGD counterpart of inflation.

3 Anomalies related to galactic dynamics

Wes Johnson sent also two links related to the long range correlation between the dynamics of quasars and galaxies. The first result was about correlations of quasar spins in billion light-year scale. Second result was about coherence between the galactic spin and motions of surrounding galaxies at least up to 6 Mly. The explanation of both findings is in terms of cosmic strings thickened to flux tubes, which are the basic element in the TGD based model for the formation of quasars and galaxies. Third anomaly relates to "too" fast spinning galaxies.

3.1 Correlated galactic spins in billion light-year scale

The first link is to a popular article "*Alignment of quasar polarizations with large-scale structures* (see `http://tinyurl.com/rcoam7g`) telling about alignment of quasar polarization with large scale structure in scale of Gly, which is a really huge scale. This suggests that the quasar spin axes are aligned with a linear structure connecting the quasars.

The correlations between spin directions of quasars over distances of billion light-years have been observed. These correlations have been observed earlier over much shorter distances for quasars/galaxies along the well-known linear structures. This suggests that the linear structures are much longer than previously thought.

This is what I have been preaching for decades. There would exist a fractal tensor network of cosmic string/monopole flux tubes over entire cosmos having local flux tube tangles as nodes. Networks inside networks inside.... The flux tubes would carry dark matter in TGD sense making possible quantum coherence in arbitrarily long length scales.

1. TGD predicts a fractal hierarchy of flux tubes formed from cosmic strings: 4-D surfaces in $M^4 \times CP_2$ having 2-D strings world sheet as M^4 projection.

2. Galaxies reside along linear structures which would correspond to what I call cosmic strings: galaxies would be tangles along these strings thickened locally to monopole flux tubes: part of their magnetic energy would have transformed partially to matter and formed the visible part of galaxy. Volume energy would correspond to length scale dependent cosmological constant. They would explain also flat velocity spectra associated with spiral galaxies. There would be no dark matter halo.

   Cosmic strings and their monopole flux tube portions would be remnant from cosmic string dominated period, which transformed to GRT type cosmology via an inflation type period as cosmic strings thickened to flux tubes. These strings containing the galaxies as tangles would form a network correlating the dynamics of individual galaxies and making possible correlations and synchrony even over distances of about 1 billion ly.

3. The correlations between spin directions of galaxies is what has been been could be inherited from past when the galaxies along strings were much closer to each other. Angular momentum conservation would take care that correlation are preserved.

4. Macroscopic quantum coherence even in cosmological scales is however possible by hierarchy of Planck constants explaining dark matter as $h_{eff} = n \times h_0$ phases of ordinary matter. We could be seeing quantum coherence of dark matter inducing ordinary coherence of matter in cosmic scales.

Remark: I have asked whether all self-organization phenomena involving energy feed (needed to increase h_{eff} responsible for quantal long range correlations at dark level) could be induced by dark matter at magnetic flux tubes [23]. A further interesting question is whether self-organization is dissipation in reversed time direction so that also it would be due to second law but in generalized sense required by ZEO.

3.2 Mysterious coherence in several-megaparsec scales between galaxy rotation and neighbor motion

Second link was to article "*Mysterious Coherence in Several-megaparsec Scales between Galaxy Rotation and Neighbor Motion*" by Lee et al (see `http://tinyurl.com/sbmcn6g`). The article states that there is a "mysterious" coherence between the rotational direction of galaxy and the average motion of its nearest neighbours within 6 MPc, possibly even up to 11 MPc. This coherence cannot result from collisions with nearby galaxies like coherence below 1 MPc and is proposed to originate from the collective motion of a structure containing the galaxies affecting the directions of angular momenta of galaxies: the coherence would be induced from that of the collective motion.

In TGD framework the natural identification for the collective structure would be as a long monopole flux tube containing the galaxies or at least a subset of them as tangles. There could be of course several monopole flux tubes in the sample studied. It was indeed found that the coherence was especially strong when neighbors of the galaxy at center were restricted to red galaxies. Red galaxies could correspond to the same flux tube. Alternatively, the collective motion affects them less than other galaxies as the article suggests.

3.3 Galaxies spinning "too" fast

The anomalous findings relating to cosmology and astronomy are proliferating I am grateful for Wes Johnson for a flow of links. This particular link (see `http://tinyurl.com/qv2vpw3`) gives pictures provided by NASA about spiral galaxies spinning "too" fast. The problem is that centrifugal acceleration destabilizes the system spinning too fast. This suggests that the structure of galaxy is not what our models involving ordinary matter and dark matter halo are somehow wrong. TGD suggests an improved view allowing to understand also "too" fast spinning rates.

Suppose that galaxies are tangles along monopole cosmic string such that string has thickened to flux tube. Monopole cosmic string would be rotating. These monopole tangles would serve as TGD counterparts for the magnetic field of galaxy which has no Maxwellian counterpart. No currents are needed for their maintenance.

1. Monopole flux tube has closed cross section, which is non-contractible 2-surface, pinch is impossible. In other words, the conservation of monopole flux prevents its splitting so that centrifugal acceleration cannot break the flux tube even at the highest spinning velocities. Only radial deformation increasing the size is possible.

2. Ordinary matter - generated as the magnetic energy of the flux tubes has transformed to ordinary matter in process analogous to inflation - in turn is gravitationally bound with the flux tube so that the galaxy manages to keep also the ordinary matter.

3.4 Galaxy which existed 1 billion years after Big Bang

Galaxy GN-z11 (see `http://tinyurl.com/tg7sscu`) existed 1 billion years after the Big Bang and gave rise to stars with a rate much faster than Milky Way. There should have been any stars giving rise to the galaxies by the usual mechanism of gravitational condensation.

TGD explanation is simple. Galaxies formed as tangles to long cosmic string, which thickened and liberated part of its magnetic energy to ordinary matter, which formed the stars of the galaxy as local

tangles inside tangle. The formation of stars was faster because local cosmological constant was larger and the rate for the transformation of magnetic energy to ordinary matter was higher. The periods of star formation should correspond to the phase transitions decreasing the local cosmological constant.

Also in younger galaxies the star formation is highest near the galactic blackhole, even at distances smaller than 3 ly, where it should not happen at all. The mechanism would be the same. For the flux tubes extending farther from galactic center the local cosmogical constant is smaller and the rate for the formation of stars is slower.

4 Local super-cluster Laniakea as flux tube structure

In the following I try to concretize the ideas about monopole flux tube network as a basic structure behind formation of astrophysical structures by discussing the supercluster Laniakea in this framework (the idea came from the question of Wes Johnson about how I understand Laniakea in TGD framework). There are two excellent videos about Laniakea (see `https://www.youtube.com/watch?v=rENyyRwxpHo` and `http://tinyurl.com/ufvw6v5`).

Consider first the structure of Laniakea.

1. Wikipedia contains a nice article about Laniakea (see `http://tinyurl.com/zfphldm`). Laniakea is a local supercluster containing also Milky Way so that it is own home supercluster. Local supercluster is defined as a basin of a local flow of galaxies directed to the center of the super-cluster.

   There is a video giving view about the structure and dynamics of Laniakea is warmly recommended (see `https://vimeo.com/104910552`). Laniakea contains about 10^5 galaxies, decomposes to four smaller super-cluster like entities and contains about 500 galaxy clusters.

2. The general picture supports the idea about fractal spaghetti formed by monopole flux tube or several of them. The presence of four smaller super-cluster type entities suggests quadrupole field as a rough starting point as one tries to gues the analog as field line topology. The first very naive guess is that the tangle defining the supercluster represents roughly the topology of quadrupole magnetic field in the first approximation: there would be pair of dipoles. One cannot of course fix the number of cosmic strings.

   The simplest starting point hypothesis is that there is just single closed cosmic string forming a structure analogous to that of quadrupole magnetic field. Reconnection can split smaller closed cosmic string from a closed cosmic string and this could correspond to a decay of galaxy to smaller galaxies. Therefore single cosmic string is certainly an approximation.

   Remark: Recall that cosmic strings are closed and one can have for instance helical structures: say two closed cosmic strings analogous to DNA double strands or single closed single having strands as pieces of it.

   Remark: Also non-monopole flux tubes are involved and the proposal is that gravitational interactions are mediated along these flux tubes emanating radially from the source. The flux for them is vanishing and there is no current needed to create the field. These flux tubes are not topologically stable against splitting.

3. Cosmic strings are assumed to form a fractal hierarchy and that in TGD inspired biology cosmic strings thickened to monopole flux tubes are behind various linear biomolecules organized around them as ordinary matter. This leads to ask whether DNA double strand and the organization of DNA double strands to chromosomes might be more general phenomenon. Chromosomes consist of 4 strands, which allows to ask whether something similar happens even at the level of superclusters and that the topology of quadrupole field is involved.

   Interestingly, also Milky Way consists of four arms assignable spiral density waves for ordinary matter so that it is not clear whether the arms can be assigned with four poles of quadrupole.

Fermi spheres are a peculiarity Milky Way possibly possibly related to a quadrupole structure of monopole flux tube topology suggesting two cosmic strings meeting at the nucleus of galaxy. There is evidence that Milky Way could be seen as being formed in a kind of cosmic collision. I have asked whether this is due to a cosmic highway accident at crossroad at which two cosmic string are pass by very near to each other is in question. This could make sense if tangle as a quadrupole corresponds to two dipoles.

Consider next the dynamics of Laniakea. Reader can build his/her own views with the help of the beautiful videos (see `https://www.youtube.com/watch?v=rENyyRwxpHo` and `http://tinyurl.com/ufvw6v5`) demonstrating the velocity flow of visible parts of galaxies, which would be associated with tangles moving along cosmic strings.

1. Wikipedia mentions that Laniakea is not gravitationally bound. Also this suggests that the galaxies associated with it are tangles of one or more cosmic strings. The dynamics would correspond to s motion in gravitational field with constraint forcing the galaxy to move along the cosmic string.

2. The motion of galactic tangles and that of ordinary matter formed from it along cosmic string is free in absence of external forces: this distinguishes TGD from halo model having a spherical symmetry. This would mean rather lose binding but strong correlation produced by the cosmic string. Most galaxy motions are directed inward towards Great Attractor: this would have explanation in terms of gravitational attraction. A good guess is that motion are along flux tube/cosmic string.

References

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

[2] Mead LR Ringermacher HI. Observation of Discrete Oscillations in a Model-independent Plot of Cosmological Scale Factor vs. Lookback Time and a Scalar Field Model. Available at: `http://arxiv.org/abs/1502.06140`, 2015.

[3] Banados E et al. A Metal-poor Damped Lyα System at Redshift 6.4. *The Astrophysical Journal.* Available at:*http://tinyurl.com/qkk26dv*, 885(1), 2019.

[4] Sauval J Scott P Asplund M, Grevesse N. The Chemical Composition of the Sun. *Annual Review of Astronomy and Astrophysics.*Available at*: https://doi.org/10.1146/annurev.astro.46.060407.145222*, 47:481–522, 2009.

[5] Pober JC et al. First Season MWA Phase II EoR Power Spectrum Results at Redshift 7. arXiv:1911.10216 [astro-ph]. Available at:`https://arxiv.org/abs/1911.10216`, 2019.

[6] Ferguson JF Asplund M Serenelli AM, Basu S. New Solar Composition: The Problem With Solar Models Revisited. arXiv:0909.2668 [astro-ph]. Available at:`https://arxiv.org/pdf/0909.2668.pdf`, 2009.

[7] Zyga L. Discovery that quasars don't show time dilation mystifies astronomers. Available at: `http://www.physorg.com/news190027752.html`, 2010.

[8] Hawkins MR. On time dilation in quasar light curves. *Month Not R Astron Soc.* Available at: `http://www3.interscience.wiley.com/journal/123345710/abstract`, 405(3):1940–1946, 2010.

[9] Pitkänen M. Quantum Astrophysics. In *Physics in Many-Sheeted Space-Time*. Online book. Available at: `http://www.tgdtheory.fi/tgdhtml/tgdclass.html#qastro`, 2006.

[10] Pitkänen M. TGD and Astrophysics. In *Physics in Many-Sheeted Space-Time*. Online book. Available at: http://www.tgdtheory.fi/tgdhtml/tgdclass.html#astro, 2006.

[11] Pitkänen M. Criticality and dark matter. In *Hyper-finite Factors and Dark Matter Hierarchy*. Online book. Available at: http://www.tgdtheory.fi/tgdhtml/neuplanck.html#qcritdark, 2014.

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

[13] Pitkänen M. More about TGD Inspired Cosmology. In *Physics in Many-Sheeted Space-Time*. Online book. Available at: http://www.tgdtheory.fi/tgdhtml/tgdclass.html#cosmomore, 2016.

[14] Pitkänen M. About the Nottale's formula for h_{gr} and the possibility that Planck length l_P and CP_2 length R are identical giving $G = R^2/\hbar_{eff}$. In *Hyper-finite Factors and Dark Matter Hierarchy*. Online book. Available at: http://www.tgdtheory.fi/tgdhtml/neuplanck.html#vzerovariableG, 2018.

[15] Pitkänen M. How the hierarchy of Planck constants might relate to the almost vacuum degeneracy for twistor lift of TGD? Available at: http://tgdtheory.fi/public_html/articles/hgrtwistor.pdf, 2016.

[16] Pitkänen M. Strong support for TGD based model of cold fusion from the recent article of Holmlid and Kotzias. Available at: http://tgdtheory.fi/public_html/articles/holmilidnew.pdf, 2016.

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

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

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

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

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

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

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

[24] Pitkänen M. Could Mars have intra-planetary life? Available at: http://tgdtheory.fi/public_html/articles/Mars.pdf, 2019.

[25] Pitkänen M. Solar Metallicity Problem from TGD Perspective. Available at: http://tgdtheory.fi/public_html/articles/darkcore.pdf, 2019.

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