Cosmic string model for the formation of galaxies and stars

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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}: 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 re-incarnates 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.

Contents

1 Introduction

The view about the role of new nuclear physics predicted by TGD in the model of solar interior [L20] 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 $H = M^4xCP_2$. 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 [L2] 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 [L20].

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 [E19] (see (`http://tinyurl.com/oqcn2hp`) discussed from TGD point of view in [K6].

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 [L12] allowing to understand Cambrian Explosion is one application of TGD based quantum cosmology.

1.2 The notion of length scale dependent cosmological constant

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 [L2].

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 [L2] . 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 [L14].

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 scale 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 [L3, L5]: 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 [L20] (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 $\hbar_{gr}$: 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.

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2 Blackholes, quasars, and galactic blackholes

I have discussed a model of quasars in [L14] (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 [L20] deriving from the 10 year old nuclear physics anomaly [E3, E20].

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 [**?**].

   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 [L20] 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 [L6, L7]. 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 Magnetars in TGD framework

There is an interesting popular article about magnetars in Quanta Magazine (`http://tinyurl.com/uh5r3az`). The article tells about the latest findings of Zhou and Vink and colleagues [E15] (`http://tinyurl.com/s24dq23`) giving hints about the mechanism generating the huge magnetic fields of magnetars.

Neutron stars have surface magnetic field of order 10^8 Tesla. Magnetars have surface magnetic field stronger by a factor 1000 - of order 10^{11} Tesla. The mechanism giving rise to so strong magnetic fields at the surface of neutron star is poorly understood. Dynamo mechanism is the first option. The rapidly rotating currents at the surface of neutron star would generate the magnetic field. Second model assumes that some stars simply have strong magnetic fields and the strength of these magnetic fields can vary even by factor of order 1000. Magnetars and neutron stars would inherit these magnetic fields. The model should also explain why some stars should have so strong magnetic fields - what is the mechanism generating them. In Maxwellian world currents would be needed in any case and some kind of dynamo model suggests itself.

Dynamo model requires very rapid rotation with rotation frequency measured using millisecond as a natural unit. The fast rotation rate predicts that magnetars are produced in more energetic explosions than neutron stars. The empirical findings however support the view that there is no difference between supernovas producing magnetars and neutron stars. Therefore it would seem that the model assuming inherited magnetic fields is favored.

What says TGD? TGD view about magnetic fields differs from Maxwellian view and this allows to understand the huge magnetic without dynamo mechanism and could give a justification for the inheritance model.

1. TGD predicts that magnetic field decomposes to topological field quanta - flux tubes and sheets - magnetic flux tubes carry quantized magnetic flux. Flux tubes can have as cross section either open disk (or disk with holes) or closed surface not possible in Minkowskian space-time. The cross section can be sphere or sphere with handles.

2. If the cross section is disk a current at its boundaries is needed to create the flux. If the cross section is closed surface, no current is needed and magnetic flux is stable against dissipation and flux tube itself is stable against pinching by flux conservation. These monopole fluxes could explain the fact that there are magnetic fields in cosmological scales not possible in Maxwellian theory since the currents should be random in cosmological scales.

   This also solves the maintenance problem of the Earth's magnetic field. Its monopole part would stable and 2/5 of the entire magnetic field $B_E = .5$ Gauss from TGD based model of quantum biology involving endogenous magnetic field $B_{end} = .2$ Gauss identifiable in terms of monopole flux.

The model for the formation of astrophysical objects in various scales such as galaxies and stars and even planets and also for quantum biology relies crucially on monopole fluxes.

1. The proposal made in [L17] is that stars correspond tangles formed to long monopole flux tube. Reconnection could of course give rise to closed short flux tubes and one would have kind of spaghetti.

   The interior of Sun would contain flux tubes containing dark nuclei as nucleon sequences and one ends up to a modification of the model of nuclear fusion based on the excitation of dark nuclei [L20]. The model solvs a 10 year old anomaly of nuclear physics of solar core [E3, E20]. From the TGD based model of "cold fusion" one obtains the estimate that the flux tube radius is of order electron Compton length, and thus about $h_{eff}/h_0 \simeq m_p/m_e \sim 2000$ times longer than proton Compton length. This has been assumed also in the model of stars discussed in [L17].

2. The final states of stars could correspond to a volume filling spaghettis of flux tube analogous to blackhole. They would be characterized by the radius of the flux tube, which would naturally correspond to a p-adic length scale $L(k) \propto 2^{k/2}$: one could speak of various kinds of blackhole like entities (BHEs). There radius of the flux tube would be scaled up by the value of effective Planck constant $h_{eff} = n \times h_0$ so that one would have $n \propto 2^{k/2}$ in good approximation.

3. The p-adic length scales $L(k)$, with k prime are good candidates for p-adic lengths scales. Most interesting candidates correspond to Mersenne primes and Gaussian Mersennes $M_{G,k} = (1+i)^k - 1$. Ordinary blackhole could correspond to a flux tube with radius of order Compton of proton corresponding to the p-adic length scale $L(107)$.

   For neutron star the first guess would be as the p-adic length scale $L(127)$ of electron from the model of Sun. $L(113)$ assignable to nuclei and corresponding to Gaussian Mersenne is also a good candidate for magnetar's p-adic length scale. $L(109)$ assigned to deuteron would correspond to an object very near to blackhole corresponding to $L(107)$ [L17]. Also the surface and interior of BHE would carry enormous monopole fluxes 32 times stronger than for magnetars.

   The are just guesses but bringing in quantized monopole fluxes together with p-adic length scale hypothesis allows to develop a quantitative picture.

Consider first the flux quantization hypothesis more precisely.

1. The observation that to the vision about monopole magnetic fields and hierarchy of Planck constants now derivable from adelic physics was that the irradiation of vertebrate brain by ELF frequencies induces physiological and behavioral effects which look like quantal. As if cyclotron transitions in endogenous magnetic field $B_{end} = 2B_E/5 \simeq 0.2$ Gauss would have been in question. The energies of photons involved are however ridiculously small and cannot have any effects. The proposal was that the effective value of Planck constant is quantized: $h_{eff} = nh_0$ and can have very large values in living matter. The energies $E = h_{eff}f$ of photons could thus be over thermal threshold and have effects. The matter with non-standard value of h_{eff} would correspond to dark matter.

2. One can make the picture more quantitative by considering the quantization of flux. The radius r of a flux tube carrying unit magnetic flux is known as magnetic length $r^2 = \Phi_0/e\pi B$, where Φ_0 corresponds to minimal quantized flux $\Phi_0 = BS = B\pi r^2 = n \times \hbar/eB$ for flux tube having disk D^2 as cross section. If B_{end} is ordinary Maxwellian flux one obtains for $B_{end} = 0.2$ Gauss $r = 5.8$ μm which is rather near to $L(169) = 5 \times 10^{-6}$ μm Cell membrane length scale $L(151) = 10$ nm corresponds to the scaling $B_{end} \rightarrow 2^{18}B_{end} \simeq 5$ Tesla and 1 Tesla corresponds to the magnetic length $r = 2.23 \times L(151)$.

   One can argue that one must have quantization of flux as multiples of h_{eff}. The geometric interpretation is that $\hbar_{eff} = n\hbar_0$ corresponds to n-sheeted structure (Galois covering) and the above quantization gives flux for a single sheet. The total flux as sum of these fluxes is indeed proportional to $\hbar_{eff}$.

3. For monopole flux tubes disk D^2 is replaced with sphere S^2 and the area $S = \pi \times r^2$ in magnetic flux is replaced with $S = 4\pi r^2$. This means scaling $r \rightarrow r/2$ for the magnetic length. The p-adic length scale becomes $L(167)$, which corresponds to Gaussian Mersenne is indeed the scale that might have hoped whereas the ordinary flux quantization giving $L(169)$ was a disappointment. This gives a solution to a longstanding puzzle why $L(169)$ instead of $L(167)$ and additional support for monopole flux tubes in living matter. As a matter of fact, there are four Gaussian Mersennes corresponding to $k \in \{151, 157, 163, 167\}$ giving rise to 4 p-adic length scales in the range [10 nm, 2.5 μm] in the biologically most important length scale range. This is a number theoretic miracle.

It is useful to list some numbers for monopole flux by using the scaling $\propto 1/L^2(k) \propto 2^{-k/2}$ to get a quantitative grasp about the situation for magnetars and other final states of stars.

1. For monopole flux $L(151)$ corresponds to $2^{16}B_{end}(k = 167) \simeq 1.28$ Tesla. For ordinary flux it corresponds to 2.56 Tesla. A good mnemonic is that Tesla corresponds to $r = 1.13 \times L(151)$.

2. For neutron star one has $B \sim 10^8$ Tesla. For monopole flux this would correspond for ordinary flux magnetic length $r \simeq 1.13$ pm roughly $2.8L_e$, where $L_e = .4$ pm is electron Compton length. Note that the corresponding p-adic length scales is $L(127) = 2.5$ pm $\simeq 2.2r$ so that also interpretation in terms of $L(125)$ can be considered. For non-monopole flux one would have roughly $r = 2.26$ pm. Neutron star would be formed when all flux tubes become dark flux tubes and perhaps form single connected volume filling structure.

3. For magnetar one has magnetic field about $B = 10^{11}$ Tesla roughly 1000 times stronger than for neutron star. For monopole flux this would give $r = 30$ fm to be compared with the nuclear p-adic length scale $L(113) = 20$ fm. Could the p-adic length scale $L(109) = 2L(107) = 5$ fm correspond to a state rather near to blackhole? $L(109)$ would would have 16 times stronger surface magnetic field $B \simeq .45 \times 10^{12}$ Tesla than magnetar. For the TGD counterpart of ordinary blackhole having $k = 107$ the surface magnetic field $B \simeq 1.8 \times 10^{12}$ Tesla would be 32 times stronger than for magnetar.

All these estimates are order of magnitude estimates and p-adic lengths scale hypothesis only says something about scales.

2.4 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?

2.4.1 TGD view about blackholes

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 $k \rightarrow k-1$ 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 naïve 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 $\Lambda(k)$.

2.4.2 Quantitative support for the model of blackhole-like object as flux tube spaghetti

The TGD based model for blackhole-like object is as monopole flux tube spaghetti [L17] containing one proton per proton Compton length and filling the entire volume. There is no need to emphasize that the models means giving up the standard view of blackhole-like objects.

Consider now the estimation of the total mass of the flux tube spaghetti.

1. Assuming additivity and neglecting self-gravitation, the total mass in units of m_p is M/m_p (here $m_p \simeq m_n$ is proton mass, the star would consist of neutrons).

2. Self gravitation for a spherically symmetric mass constant distribution inside sphere of radius R and given as $\rho = M/Vol(R)$ created by the flux tube spaghetti gives to the stationary metric contribution $\Delta g_{tt} = -\Phi_{gr}$, where one has

$$\Phi_{gr}(r) = 2G\frac{2M(r)}{r} = \frac{8\pi}{3}\frac{GM}{Vol(R)}r^2 = 2GM\frac{r^2}{R^3} \quad .$$

   The gravitational potential energy of the mass distribution is in Newtonian appproximation given by

$$E_{gr} = -\int \rho(r)\Phi_{gr}(r)dV = -\frac{6GM^2}{5R} \quad .$$

   For $R = r_S = 2GM$ this gives

$$E_{gr} = -\frac{6GM^2}{10GM} = -\frac{3}{5}M \quad .$$

   Therefore the observed mass M_{obs} using m_p as a unit is given

$$M_{obs} = \frac{E_{tot}}{m} = \frac{2}{5}\frac{M}{m_p} \quad .$$

3. Suppose that the flux radius of thickness R contains a single proton per length zR so that one proton fills the volume $\pi * zR^3$. Suppose R corresponds to the proton Compton length $L_p = h/m_p$.

   Assume that $h_{eff} \neq h$ is possible so that L_p is scaled by $y = h_{eff}/h$. One would have

$$L_p(h_{eff}) = yL_p \quad .$$

4. The total mass M using m_p as unit and neglecting gravitational potential energy is given by the ratio of the volume V of the blackhole regarded as region of Minkowski space to the volume V_p taken by a single proton:

$$\frac{M}{m_p} = \frac{V}{V_p} = \frac{4}{3zy^3}(\frac{r_S}{L_p})^3 \quad .$$

   Taking into account gravitational potential energy, one obtains

$$\frac{M_{obs}}{m} = \frac{2}{5}\frac{V}{V_p} = \frac{8}{15zy^3}(\frac{r_S}{L_p})^3 \quad .$$

One can test the model for the Sun. One has $M_S = 2\times10^{30}$ kg and $r_S = 3$ km. Proton has mass $m_p = 1.6\times10^{-27}$ kg and Compton length $L_p = 1.3\times10^{-15}$ m. Substituting the values to the above formula, one obtains $(y, z) = (1, .992) \simeq (1, 1)$. In the above formula M_{obs}/m on r.h.s decreases slightly in $m_p \rightarrow m_n$ and $1/L_p^3$ also increases on t l.h.s in $m_p \rightarrow m_n$. The changes of l.h.s and r.h.s are proportional to $-\epsilon \times l.h.s$ and $3\epsilon \times r.h.s$, where one has $\epsilon = (m_n - mp)/m_p \simeq .1.811 \times 10^{-3}$. This requires $\Delta(1/z) \simeq -4\epsilon(1/z)$ so that $z = .992$ is replaced with $z_{new} = (1+4\epsilon)z \simeq .9992$, which deviates from unity by -8×10^{-4}.

The conclusion is that the simple flux tube model for $h_{eff} = h$ and neutron taking a volume of Compton length, which is definitely different from the general relatistic model, is surprisingly realistic.

2.4.3 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 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

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

   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 [E4] [K11, K9] 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

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

where $v_0 < c$ is velocity parameter. For the Bohr orbit model of the 4 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 [L11, L10] [K1]. 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 $h_{eff} = h_{gr}$

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

For $k = 107$ blackhole one obtains

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

For $m = m_p$ this gives

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

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

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

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 valueThis 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 proportiona+l to the area of the surface but using flux tube transversal area as a unit. This would give apart from numerical constant

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

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

When 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 $h_{gr} =\to h_0 = h/6$ for $h_{gr} < h_0$. This would given $GM_D m/v_0 > \hbar_{min}$ ($\hbar_{min} = \hbar$ or $\hbar/6$) leading

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

   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

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

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 $m \to xm$ and $M_D \to M_D/x$. 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.

2.4.5 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.

2.5 Zero energy ontology and stellar and galactic evolution

Zero energy ontology (ZEO) replaces ordinary ontology in TGD based view about quantum states and quantum jump [L21].

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 embedding 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 [L6] 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.

2.5.1 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 astrophysical objects do not expand but only comove. The sudden expansions should be observable and happen also for Eart. I have proposed a TGD variant of Expanding Earth hypothesis along these lines [?]

2.5.2 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 [E6] (see `http://tinyurl.com/qkk26dv`). TGD based explanation is discussed in [L20].

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 [L6] 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 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.

2.5.3 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 [E16]. 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 [E18]. 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 [K6] 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.

2.5.4 Did cosmology have any "Dark Ages"?

A further potential time anomaly of the recent cosmology relates to the "Dark Ages" of the Universe. Between the decoupling of CMB radiation from matter and the formation of stars there should have been a "Dark Ages" during 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 [E10] (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 [L17] (`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 whether "Dark Ages" still prevail in distant past.

1. In ZEO Universe consists at the level of embedding 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.$CDshaveinterpretationasahierarchyofsub-cosmologies.EachCDdefinesacorrelateforaconsciousentityandincreasesinsizeineach\small" statefunctic$ $passive-asalsomembersofstatepairsatitdefiningzeroenergystates.Theactiveboundaryrecedesfartherawa$

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.

2.5.5 Observation of a time reversal of blackhole like object?

A very strange object behaving like time reversal of blackhole has been observed (`http://tinyurl.com/umzxaoe`). The blackhole in question is super-massive and in the middle of galaxy cluster. 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 naïve 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.

2.5.6 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.

2.5.7 An objection against the notion of dark energy

Nikolina Benedikovic gave a link to a popular article (http://tinyurl.com/ydo2sna9) describing a finding challenging the notion of dark energy. This finding made by a team of astronomers working at Yonsei University (Seoul, South Korea) is very interesting since twistor lift of TGD predicts length scale dependent cosmological constant.

Let us collect the basic facts first.

1. Standard candle property (http://tinyurl.com/pn9goe2) is essential assumption leading to dark energy hypothesis. It states that the distance corrected luminosity of SN Ia supernovae does not evolve with redshift that it is it depends only on distance.

2. Observation: The luminosity of SN Ia supernova correlates significantly with the population age of the host galaxy. The luminosity thus depends on the environment provided by the host galaxy.

   According to the article:

   > The team has performed very high quality spectroscopic observations to cover most of the reported nearby early-type host galaxies of SN Ia, from which they obtained the most direct and reliable measurements of population ages for these host galaxies. They find a significant correlation between SN luminosity and stellar population age at a 99.5 percent confidence level. As such, this is the most direct and stringent test ever made for the luminosity evolution of SN Ia. Since SN progenitors in host galaxies are getting younger with redshift (look-back time), this result inevitably indicates a serious systematic bias with redshift in SN cosmology. Taken at face values, the luminosity evolution of SN is significant enough to question the very existence of dark energy. When the luminosity evolution of SN is properly taken into account, the team found that the evidence for the existence of dark energy simply goes away (see Figure 1).

3. This is in conflict with the standard candle property if the population age of the host galaxy decreases with distance. This is obvious in standard cosmology. But is this true in TGD Universe obeying zero energy ontology (ZEO)?

In ZEO [L21] (http://tinyurl.com/yfjtmoq6) the situation might be different. ZEO provides a quantum measurement theory solving the basic paradox of standard quantum measurement theory and leads to a theory of consciousness.

1. The first prediction is that geometric time and experienced time identified as sequence of "small" state function reductions (SSFRs as counterparts of weak measurements) are not same. This is of course an empirical fact - thermodynamical time is irreversible unlike geometric time, etc... but in standard ontology these times are identified.

2. In small state function reductions (SSFRs) as counterparts of weak measurements) arrow of time does not change and their sequence defines self as conscious entity. In big (ordinary) state function reductions (BSFRs) the system "dies" and reincarnates with opposite arrow of time. The experiments of Minev *et al* provide direct support for ZEO in atomic systems [L16] (http://tinyurl.com/yjbpoy3q). Libet's findings support this in neuroscience [?].

3. Assume that the size of the causal diamond (CD) decreases in "reincarnation" that is self experiences "childhood". If so the size of CD can remain bounded. Irrespective of this assumption the temporal center of mass position of CD in embedding space $H = M^4 \times CP_2$ remains the same during the sequence of reincarnations.

Most importantly: the steady motion towards future assumed in standard ontology with single arrow of time is replaced with forth-and-back motion in time with constant cm position of CD in H.

4. ZEO explains several time anomalies such stars older than the universe and the observation that the nuclear abundances of very distance stars seem to have nearly their modern values supporting the view that the population age of galaxy does not depend significantly on distance [L17](hhttp://tinyurl.com/ydlogkb4) .

   In particular, the age distribution for the populations of galaxies would not depend significantly on distance - standard candle hypothesis would be saved!

2.6 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.

2.6.1 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 [L17](see http://tinyurl.com/tkkyyd2) .

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.

"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 [L18]. 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.

2.6.2 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 counter the 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 [L21] in which the magnetic energy of flux tube transforms to ordinary matter: time reversal for the TGD counterpart of inflation.

3 A model for the formation of galaxies

I have proposed a general vision about galaxy formation as formation of tangles on cosmic strings carrying monopole flux. The strings can be long and also short. In the case of long string the model explains flat velocity spectrum of distant stars automatically. For closed short strings the velocity spectrum is not flat. There is however no detailed model for the galaxy formation. In particular, the complex structure of spiral galaxies is poorly understood. Even the question whether there is single long cosmic string orthogonal to the galactic plane or cosmic string parallel to the spiral structure in galactic plane - as proposed decades ago in the original model [K4, K12] - or both has remained open. In the sequel I make an attempt to collect the essential facts about elliptic and spiral galaxies and consider a qualitative model for the galaxy formation consistent with these facts. The goal is rather modest: just to develop an internally consistent view about the evolution of galaxies.

1. The simplest model for elliptic galaxy is as a closed string possibly reconnected as a loop from long string or as a tangle of a cosmic string having topology analogous to that of field lines of dipole magnetic field. Quasar would have preceded the formation of the tangle in which string would have thickened to flux tube and dark energy would have transformed to ordinary matter [E2] [L14]. Quasars would be time reversal of galactic blackhole like entity (GBHE).

2. In the case of spiral galaxies the existence of vast polar structures (VPOS) in the plane orthogonal to the galactic plane of spiral galaxy (`http://tinyurl.com/k553545`) strongly suggest [L9] that two cosmic strings are involved and that the spiral structure believed to correspond to a standing wave analogous to traffic jam is associated with dark matter of a long cosmic string. This model conforms with the fact that the stars of spiral galaxies are older than those of elliptic galaxies except inside the bulge.

   The asymmetry between the two planes suggests that the spiral arms are formed when an elliptic galaxy identified as a tangle of a long string $S_{||}$ formed via a quasar stage [L14] in the galactic plane has collided with a cosmic string $S_\perp$ orthogonal to the galactic plane. These collisions are unavoidable for non-parallel strings and gravitational attraction causes the needed relative motion.

   The differential rotation of portion of $S_{||}$ around $S_\perp$ would have deformed $S_{||}$ to a spiral shape. $S_{||}$ would have also generated the visible spiral arm pair in the transformation of dark energy to ordinary matter. Galactic bulge would correspond to the elliptic galaxy and galactic blackhole like entity (GBHE) would have formed from the matter in bulge: this conforms with the fact that elliptic galaxies have always galactic blackhole. The galactic bar could be analogous to the dipole of dipole magnetic field. In principle also the string orthogonal to the galactic plane could produce ordinary matter by thickening.

One open question relates to the fact that TGD predicts two kinds of cosmic strings with closed transverse cross section and having vanishing induced Kähler field or non-vanishing induced Kähler form carrying monopole flux. The latter are stable against splitting by the conservation of the monopole flux and have no counterpart in Maxwellian electrodynamics [L15]. The monopole flux tubes could correspond to the cosmic strings giving rise to galaxies, stars, and even planets as tangles. Non-monopole flux tubes might serve as gravitational flux tubes mediating gravitational interactions. Presumably both kinds of flux tubes are involved but their precise roles are not well-understood.

3.1 Some basic facts about galaxies

In the following I collect basic facts about galaxies.

3.1.1 Elliptic galaxies

The following facts about elliptic galaxies (`http://tinyurl.com/ayyvg9n`) are relevant for what follows.

1. 10-15 per cent of all galaxies are elliptic. The stars of elliptic galaxies are old and older than those of spiral galaxies outside the bulge.

2. The size of elliptic galaxies is typically 1-2 pc and therefore more than by order of magnitude smaller than that of spiral galaxies. Elliptic galaxies are essentially 3-D structures without sub-structures, and the central bulge of spiral galaxies resembles elliptical galaxy. There is no preferred galactic plane. Large enough elliptic galaxies have supermassive blackhole-like entity (BHE) at their center. Elliptic galaxies are populated by globular clusters. The motions of stars in elliptic galaxies are mostly radial.

3. Whether elliptic galaxies contain dark matter is not clear and the non-existence of dark matter cannot be excluded for elliptic galaxies (`http://tinyurl.com/s2wrd26`).

3.1.2 Basic structures for spiral galaxies

Most galaxies 85-90 per cent of galaxies are spiral galaxies. Spiral galaxies are highly structured.

Consider first the visible structure taking Milky Way as a representative example (also so called mini-spirals exist [L9]).

1. Stellar disk of spiral galaxy (`http://tinyurl.com/vx2hams`) has radius $R_D = 23 - 30$ kpc. In the case of Milky Way one can distinguish 3 different disks. The young thin disk contains young stars and has thickness of .1 kpc, which is also the size scale of globular clusters. The old thin disk has thickness of .325 pc. The thick disk has a thickness of 1.5 kpc. This gives some hints about the formation of the Milky Way.

2. Milky Way has 4 spiral arms. The arms begin from the ends of galactic bar with length 1-5 kpc. The interpretation of arms is as standing waves. Traffic jam is used analogy for arms: the stars rotating around the center of galaxy would slow down at the arm. The question is what causes the jam. For the second arm pair the number of stars is larger than for the second pair.

3. Spiral galaxies do not have bulge always (`http://tinyurl.com/tb7ca72` and `http://tinyurl.com/uv79o9x`). The bulge can contain also spiral sub-bulge in the galactic plane. The bulge is few kpc thick. Galactic blackhole (like entity) is present only if bulge is present and has in the case of Milky Way size scale of 10^4 ls (10^{-4} pc).

4. Vast polar structure - VPOS (`http://tinyurl.com/k553545`) is a disk in the plane orthogonal to the galactic plane containing satellites, which are dwarf galaxies and globular clusters and streams of stars and gas. The disk has radius 250 kpc considerably larger than stellar disk in galactic plane. Its thickness is 50-60 kpc whereas the components of galactic disk have much smaller thickness.

5. There are also stellar nebulae containing hydrogen and acting as stellar nurseries.

6. Cold dark matter scenario (`http://tinyurl.com/zv6wg4s`) leads to the conclusion that galaxy involves dense dark core radius 2-3 times that of stellar disk and having constant density and behaving like rigid body in good approximation. Dark matter halo predicts that

the density is peaked and this leads to core-cusp problem [E21]. The dark matter core could relate to the VPOS having the same thickness. Inside the core region rotation velocity should be constant if dark matter dominates.

Milky Way has a pair of Fermi bubbles located symmetrically at the opposite sides of the galactic plane and touching it. The diameter of bubble is 7.7 kpc. By the way, Earth is at the boundary of Fermi bubble (`http://tinyurl.com/r9f8nee`). The bubbles expand at velocity $v = 3.2 \times 10^{-3}c$. It is believed that the bubbles are a remnant of a very energetic event occurred for millions of years ago in the galactic center. The bubbles would not be a dynamical phenomenon rather than a morphological feature.

3.2 TGD based model

In the sequel the TGD inspired cosmology and model for the formation of galaxies is first briefly summarized, and after that a possible qualitative model for the formation of galaxies is discussed.

3.2.1 TGD inspired view about cosmology

TGD based model to be discussed relies on the general vision about cosmology.

1. Einsteinian space-time corresponds to space-time surfaces with 4-D M^4 projection. The many-sheetedness of space-time surface is lost at the QFT-GRT limit replacing the sheets with single region of M^4, whose metric is slightly deformed. The sums of the induced gauge potentials *resp.* deviations of the metric from M^4 metric define gauge fields of the standard model *resp.* metric of GRT space-time. This approximation fails for cosmic strings.

2. Cosmic strings come in two different varieties having closed transversal cross section as 2-D CP_2 projection and string world sheet as M^4 projection. The 2-D cross section can carry non-trivial monopole type Kähler flux or vanishing Kähler flux but non-vanishing electroweak gauge fields. Neither flux tube needs current to create the magnetic field since cross section is closed.

   In primordial cosmology cosmic strings of both types dominate. The cosmic strings are unstable against thickening of M^4 projection and during the analog of inflationary period meaning transition to a radiation dominated cosmology the M^4 projection becomes 4-D and Einsteinian space-time becomes a reasonable approximation in long length scales.

   Cosmic strings and thin flux tubes are however present also during Einsteinian period and cannot be completely neglected. For instance, monopole flux tubes explain the existence of magnetic fields in cosmic scales and also solve the maintenance problem of Earth's magnetic field [L1]. There are many open questions. For instance, it is not clear whether the flux tubes mediating gravitational interaction have nearly vanishing induced Kähler form and vanishing Kähler magnetic flux. It is assumed that long cosmic strings having galaxies as tangles carry monopole flux but even this assumption can be challenged.

3. Twistor lift of TGD plays a central role in the scenario. It predicts that the dimensionally reduced 6-D Kähler action for the 12-D product of twistor spaces of M^4 and CP_2 decomposes to a sum of 4-D Kähler action and volume term having cosmological constant Λ as a coefficient. Dimensional reduction is required by the induction of the twistor structure to the space-time surface as S^2 bundle.

   Λ has spectrum and is proportional to the inverse square of the p-adic length scale assumed to satisfy p-adic length scale hypothesis $p \simeq 2^k$: one can write $\Lambda = \Lambda(k)$. Thus any astrophysical system (say galaxy,star, or planet) as space-time sheet inside causal diamond (CD) is characterized by $\Lambda(k)$. This solves the basic problem due to the huge size of cosmological constant since cosmological constant goes to zero in long length scales. This also predicts the thickness of flux tubes. For "cosmological" cosmological constant the thickness is that of large neuron.

4. The thickness of the flux tube remains piecewise constant in cosmic evolution and increases in phase transitions reducing the value of $\Lambda(k)$. The simplest assumption is that the phase

transitions are induced by the expansion of the larger space-time sheet at which the subsystem is glued by CP_2 sized wormhole contacts. In the formation of blackholes these phase transition would take place in opposite direction leading to contraction. For instance, in stars the thickness of flux tubes would be larger than in blackhole like entities (BHEs) defined by the volume filling flux tubes with thickness of proton Compton length [L17].

For cosmic strings and primordial flux tubes the thickness would be presumably smaller and protons could be replaced with those of hadron physics characterized by a Mersenne prime smaller than M_{107} characterizing ordinary hadron physics. M_{89} is the Mersenne labelling the fractal copy of hadron physics in LHC energy scale and there are indications for the mesons of M_{89} hadron physics at LHC [K7, K8].

3.2.2 TGD based model for the formation of galaxies

In TGD framework the presence of VPOS (`http://tinyurl.com/k553545`) [L9] suggests the presence of long cosmic string $S_\perp$ orthogonal to the galactic plane containing dark matter and energy and at least one cosmic string $S_{||}$ thickened to flux tube parallel to the galactic plane. Single $S_{||}$ would suggest two spiral arms but there are four. Also the existence of 3 disks suggest that there are actually 2 flux tubes $S_{||,i}$, $i = 1, 2$, which would collided with $S_\perp$. Could gravitational force between cosmic strings have caused the formation of spiral structures and could visible galactic matter be generated from the thickening of these flux tubes?

One should also understand the flat velocity spectrum of distant stars. $S_\perp$ creates such a spectrum. Also $S_{||}$ creates such as spectrum for objects rotating in VPOS plane. Same is approximately true for the stars rotating in galactic plane since the dark mass of string plus its decay products within ball of given radius R (distance from the galactic center) is expected to be proportional to R. As a matter fact, the original proposal [K4, K12] was that there is only string in the galactic plane and corresponds to the spiral structure.

One should understand the morphologies of elliptic and spiral galaxies and how they were formed.

1. Elliptic galaxies are simple and older than spiral galaxies. A good guess is that they represent the primordial galaxies and are formed as tangles along cosmic strings thickening locally to flux tubes and producing the ordinary matter as dark energy and dark matter of string transforms to ordinary matter. Quasars as time reversals of blackholes would represent the primordial stages of elliptic galaxies [L14]. That there are also small elliptic galaxies without GBHE supports the view that time reversal is in question.

2. Spiral galaxies with much complex morphology would be an outcome of dynamical processes involving collisions. The bulge of the spiral galaxy resembles elliptic galaxy, which gives hints about the dynamics involved with the formation of the spiral galaxy.

   The presence of VPOS and strong asymmetry between the VPOS plane orthogonal to the galactic plane strongly suggests a collision of elliptic galaxy assignable to cosmic string $S_{||}$ with some object The simplest identification of this object is as $S_{||}$, which has remained mostly dark but shows itself as a preferred direction for galactic jets. Indeed, two strings not parallel to each other and moving with respect to each other are doomed to intersect and intersection would give rise to spiral galaxy. The relative motion would be caused by the gravitational attraction of the strings.

3. Spiral morphology should be understood. Why 4 spiral arms? Why a pair of dense spiral arms with members connected by galactic bar to connected structure? Why the pair of less dense spiral arms forming similar connected structure? Are the pairs separate structures or parts of the same structure and could bulge show the existence of sub-structure consistent with the fusion of two elliptic bulges. Could the existence the 3 disks with different ages and thicknesses relate to the existence of 3 strings?

   Could the VPOS cosmic string(s) $S_{||}$ ($S_{||,i}$) in the galactic plane have rotated differentially with respect to the cosmic string $S_\perp$ orthogonal to the galactic plane and given rise to a pair of spiral arms. Are 2 parallel strings $S_{II,1}$ and $S_{||,2}$ in galactic plane needed to explain both pairs of spiral arms.

One must understand the asymmetry between $S_\perp$ and $S_{||,i}$. Did $S_{||,i}$ contain a tangle giving rise to elliptic galaxy by the transformation of dark matter to ordinary matter. Did the elliptic galaxy become the bulge of the spiral galaxy? Did $S_\perp$ collide $S_{||,i}$. Did $S_{||,i}$ start differential rotation around the long string and give rise to spiral structure with two arms connected by the bar?

The gravitational attraction between $S_\perp$ and $S_{||,i}$ should have increased the probability of the collisions - 85-90 per cent of galaxies are spiral galaxies. Gravitational attraction could have made possible also the second collision in which the less dense pair of arms emerged and gave rise to the thin disk.

4. One should understand galactic bar. Bar brings in mind is dipole creating dipole magnetic field. Could one have the analog of dipole field with monopole flux tubes needing not current to generate it and perhaps assignable to $S_{||,i}$. Could dark flux tubes associated with $S_{||,i}$ give rise to flux tube structures with topology resembling that of dipole magnetic field?

   Remark: The dipole nature for dark monopole flux structure is somewhat ad hoc assumption since there would be no current as source. There are also flux tubes carrying vanishing total flux and correspond to thickening of flux tubes. A possible interpretation would be as flux tubes mediating gravitational interaction and characterized by very large value of $h_{eff} = h_{gr} = GMm/v_0$ [E4] [K11, K1] [L11]. The dipole like flux tube structure could correspond to these flux tubes.

5. What about galactic blackhole, which in TGD would correspond to galactic black-hole like entity (GBHE) identifiable as volume filling flux tube structure [L17]. TGD actually suggests a hierarchy of BHEs classifiable by the thickness of the volume filling flux tube and ordinary stellar blackholes would correspond to flux tubes for which proton Compton length would define the thickness. An important empirical input comes from the fact that GBHE is present only if also the galactic bulge is present, and that elliptic galaxies have GBHE as a rule. This also supports the view that GBHE is formed after the formation of elliptic galaxy which could take place via a formation of quasar in which dark matter transforms to ordinary matter in a process which is time reversal for the formation of blackhole: white hole like entity (WHE) might be appropriate term in the case of quasar [L14].

6. The presence of old thick disk, thin disk, and young thin disk suggest interpretation as bulge (elliptic galaxy), younger portion of the same string $S_{||,1}$ decaying to ordinary matter and leaving the string, and possibly portion of $S_{||,2}$ suffering similar decay. This interpretation would suggest that the dwarf galaxies and globular clusters in VPOS have been there from the beginning and are not generated from $S_{||,i}$.

7. How satellites - dwarf galaxies and globular clusters - are formed? Are they basically bound states of closed strings with VPOS string. Have they reconnected from VPOS string as separate loops? Did reconnections of this VPOS string produce dwarf galaxies or were they there from beginning as satellites. Note that the number of stars about one thousandth from that for galaxies and globular clusters have size scale .1 kPc.

The core-cusp problem of cold dark matter model [E21] gives guidelines for the model building. The existence of dark core (DC) with approximately constant density with radius 2-3 times that of stellar disk is suggestive: it should have density peaked at center instead of constant density: this leads to the halo-cusp problem.

1. TGD suggests that the dark matter of astrophysical objects have as asymptotic states volume filling flux tube spaghettis [L17] (`http://tinyurl.com/tkkyyd2`). The size R of the spaghetti correlates with the thickness r of the flux tube. Dark matter dense core associated with strings should form a spaghetti with size $R \sim 90$ kpc few times the size of the stellar disk. GBH would be spaghetti with radius about $R_{GBH} \sim 10^{-4}$ pc with flux tube thickness given by proton Compton wavelength $L_p \sim 10^{-15}$ m.

   By scaling the thickness L_p of flux tube of GBH by factor $R/R_{GBH} \sim 10^9$ one obtains dark flux tube radius about $r \sim 10^{-6}$ m - the size scale of cell nucleus by the way. Recall that flux tube thickness 10^{-4} m corresponding the size scale of large neutron is assignable with "cosmological" cosmological constant Λ. Note that $\Lambda(k)$ is length scale dependent in TGD and characterizes the system's causal diamond as "sub-cosmology".

2. There are several open questions. Either $S_{||,i}$ or $S_\perp$ could give rise DC. Which of them? $S_\perp$ makes itself visible only via the presence of galactic jets and as structures along which galaxies form linear structures. Why so passive role? Does dense core correspond to a flux tube tangle possibly having the topological structure of field lines of a dipole magnetic field? Can the flux tube structure be disjoint from the long string - perhaps formed in reconnection?

3.3 Support for the proposed model of galaxies

In the following some empirical support for the proposed model is discussed.

3.3.1 Evidence for 3 different temperatures at galactic halo

The model for Milky Way suggests the presence of 3 cosmic strings thickened to flux tubes. Galactic disk has indeed 3 components with different thickness. There is support for the presence of 3 components also in the Milky Way halo [E11] (`http://tinyurl.com/ssxl3ux`, thanks to Wes Johnson for the link) as gas at different temperatures, and perhaps assignable to 3 different cosmic strings.

The information was gained by studying X rays from a blazar, very active energetic core of a distant galaxy emitting intense beams of light. The blazar was at distance of 5 billion light years. The light passed through the galactic halo and the temperature of the halo was determined from the properties of light received at Earth.

The halo was expected to have single temperature in the range between $10^4 - 10^6$ K. It was however found to contain 3 components at different temperatures, and the hottest component had temperature about 10^7 K. The unexpectedly high temperature is proposed to be due to the winds emanating from the disc of stars of MW. It was also found that the halo contains besides hydrogen also significant amounts of heavier elements suggesting that the halo has received material created by certain stars during their lifetime and final stages.

In TGD framework "cold fusion" [L5] outside stellar interiors could have generated at least part of the heavier elements. "Cold fusion" proceeds by a formation of dark nuclei identifiable as dark nucleon sequences at magnetic flux tubes with $h_{eff}/h \simeq m_p/m_e \sim 2000$ and having radius of electron Compton length. Nuclear binding energy is scaled down by a factor of about 1/2000 to keV range. Dark nuclei would have transformed to ordinary nuclei liberating practically all nuclear binding energy outside stellar nuclei. This process would serve as a kind of warm-up band in the pre-stellar evolution leading eventually to the ordinary fusion [L5, L20, L17].

3.3.2 Evidence for the presence of monopole flux tubes

Monopole flux is the key property of flux tubes proposed to be behind various astrophysical structures. Is there any direct evidence for this? Evidence has emerged for the existence of giant clouds with size about 100 AU in the vicinity of the supermassive GBHE of Milky Way [E7] (`http://tinyurl.com/sukomc6` and `http://tinyurl.com/tz2hta5`). These objects - called G objects - look like gas clouds but behave like stars. G objects stretch longer when nearer to GBHE but get their original shape when farther away. One would expect that they are torn apart by the enormous tidal forces created by GBHE.

The identification could be as visible matter assignable to a spaghetti like structure formed by monopole like flux tube, which could have also produced the visible matter in the thickening of the flux tube. By flux conservation the monopole flux prevents the flux tubes from splitting even in the huge gravitational field of supermassive GBHE. Without monopole flux tubes to which visible matter is gravitationally bound the structure would be torn to pieces. In Maxwellian world monopole flux tubes are not possible. In biology the behavior of gels (the contents of an egg is the basic example) could be based on monopole flux tubes connecting the cells together.

3.3.3 Cosmic strings and angular momentum problem of General Relativity

Vladimir Nechitailo took contact and asked for comments about his World-Universe model (WUM) (http://tinyurl.com/vm2k7hb). In the following my reaction to the claim

"The angular momentum problem is one of the most critical problems in BBM. Standard Cosmology cannot explain how Galaxies and Extra Solar systems obtained their substantial orbital and rotational angular momenta, and why the orbital momentum of Jupiter is considerably larger than the rotational momentum of the Sun. WUM is the only cosmological model in existence that is consistent with the Law of Conservation of Angular Momentum. "
appearing in the abstract of his article.

I cannot quite agree with this statement.

I have not explicitly considered the problem of large angular momenta in TGD. I do not think that the problem is non-conservation - note however that general relativity has problem with classical conservation laws which led to the idea about space-times as surfaces in $M^4 \times S$.

The challenge is to explain naturally the large angular momenta, which obey the analog of stringy mass formula: mass squared proportional to angular momentum. In TGD framework monopole flux tubes made possible by the homology of CP_2 lead to a picture in which cosmic strings with huge string tension carrying magnetic and volume energy thicken to flux tubes, and in this process lose magnetic energy transform to ordinary matter.

Cosmic strings [K4, K12, K6] explain dark matter and energy: galaxies are associated as tangles to long cosmic strings and the gravitational field of long cosmic string explains the flat velocity spectrum of distant stars [L4, L9, L17] (http://tinyurl.com/tkkyyd2. The rotation of the galactic matter around the long cosmic string explains the large angular momenta. For halo models one does not obtain this prediction. Large angular momenta are of course associated also to distant stars with constant velocity.

WUM as primordial period of cosmology is in TGD replaced with cosmic strings as non-Einsteinian 4-D space-times surfaces with with 2-D M^4 projection and complex manifold of CP_2 as CP_2 projection would dominate the primordial cosmology transforming to radiation dominated cosmology by the thickening of M^4 projection of cosmic string to 4-D [K6, L4]. This period would be the analog of inflation in TGD but without inflaton fields. Dark matter would correspond to $h_{eff} = n \times h_0$ phases at flux tubes present in all scales - even biological and also hadronic scales - as remnants of the primordial period.

3.3.4 Too young to be so heavy

The model should also allow to understand quasars and in [L14] (http://tinyurl.com/y2jbru4k) I considered a model of quasars as precedessors of galaxies. And additional support for the proposed picture came from a rather thought provoking article (http://tinyurl.com/sz9n72n) telling about a particular quasar identified as a super-massive blackhole with mass $.780 M(Sun)$ ($M(Sun)$ is solar mass). Quite generally quasar masses vary in the range $10^8 - 10^9$ $M(Sun)$. Galactic blackholes have mass in the range $10^5 - 10^9$ $M(Sun)$. Milky Way blackhole has much smaller mass about $4 \times 10^6 M(Sun)$ (http://tinyurl.com/7wtza99).

Remark: I prefer to talk about blackhole like entities (BHEs): the TGD view about BHEs see is described in [L17] (http://tinyurl.com/tkkyyd2).

1. The first question considered by the researches is what burned away the neutral fog around the BHE: it is known that re-ionization (http://tinyurl.com/y8xodylx) must have burned away the fog ending the "dark ages" during which the Universe was transparent but there were no sources of light, which we could see (cosmic redhsift). Dark ages ended when re-ionization took place by light burning away the fog - perhaps light coming from dwarf galaxies and high energy photons from quasars did this. Despite re-onization the light could propagate since the density of matter absorbing it was so low.

2. There is also second deep problem: quasar - if indeed BHE - is too massive quite too early. This problem is met for all quasars - the age of the universe is measures using 1 billion years as a natural time unit for the observed quasars. If the galactic blackholes were former quasars, their masses should be larger than for quasars. The mass of Milky Way BHE is however of order $10^6 M(Sun)$ and much smaller than for quasars.

From the list of blackholes (`http://tinyurl.com/s3e223q`) one gets an idea about the masses of galactic BHEs. Typically masses are considerably lower than quasar masses. There is however lenticular (between elliptic and spiral galaxy having disk but not spiral structure) galaxy NGC 1277 with galactic blackhole with mass about $1.7 \times 10^{10} M(Sun)$.

The smaller mass scale makes it is difficult to believe that galactic blackholes could be former quasars. One can also ask whether very old lenticular galaxies, which posses neither spiral structure but have galactic plane could be formed from quasars and whether the central object could be quasar.

These problems challenge the interpretation of quasars as BHEs and TGD suggests an interpretation of all quasars as time reversals of BHEs - whitehole like entities (WHEs). Zero energy ontology (ZEO) of TGD indeed allows time reversed states and the arrow of time changes in ordinary, “big” state function reductions (BSFRs), which in TGD Universe can occur even in astrophysical scales so that even BHEs could be time reversals of WHEs. BSFRs would occur routinely in living matter, and self-organization as a process in apparent conflict with second law could be based on time reversal at magnetic body (MB) carrying dark matter as $h_{eff} = n \times h_0$ phases. Self-organization would be based on dissipation with reversed arrow of time at MB and violate standard arrow of time. In accordance with experimental facts, it would require energy feed since the creation of states with non-standard value of h_{eff} requires energy feed.

ZEO allows to imagine two solutions to the problem of “too-young-to- be-so-heavy” problem.

1. Quasars could be WHEs [L14] (`http://tinyurl.com/y2jbru4k`) and they would feed matter to environment rather that eating it (there was not much to eat yet!). The dark energy and matter of a tangled of cosmic string would transform to ordinary matter eventually creating the visible galaxy as the tangle thickens to magnetic flux tube and loses its energy. The precedessors of quasars would be generated during inflationary period as tangles of cosmic strings of primordial cosmology started to thicken and Einsteinian space-time with 4-D M^4 projection in $H = M^4 \times CP_2$ was created. Before this it was 2-D string world sheet. The fog, presumably hydrogen around the quasar formed from cosmic string energy, was formed from the energy of cosmic string.

   The huge energy emission by quasars could accompany a reduction of length scale dependent cosmological constant leading to the emission of volume energy whose density is proportional to cosmological constant.

2. One can also imagine that quasars were indeed BHEs which got their mass from the material produced by the decaying cosmic strings before stars were even formed. This would be less radical option than the first one and require that BHEs of galactic nuclei started to form much later than quasars and have therefore much smaller masses. They are however present in all elliptic galaxies except dwarfs. Elliptic galaxies are rather old and could have perhaps formed as self-intersections of the flux tube tangle giving rise to the elliptic galaxy.

3.3.5 Surprises from Milky Way

The continual feed of unexpected observations has forced a critical re-evaluation of what we really know about galaxies and their formation. The standard wisdom that they are due a condensation of matter under gravitational attraction is challenged.

Even the Milky Way is yielding one surprise after another. It is amusing to witness how empirical findings are gradually leaving TGD as the only viable option. The surprise that inspired these comments, came from Science Alert (`https://cutt.ly/KQPo8ZV`). The article tells at layman level about the findings reported in an article accepted to The Astrophysical Journal Letters [E9] (`https://cutt.ly/MQPpq4V`).

The discovery of the largest gas filament in our Galaxy, or a new spiral arm?

Cattail is a gigantic structure with a length which can be as much as 16,300 light-years, discovered in the Milky Way. It is a filament which does not seem to be analogous to a spiral arm since it does not follow the warping of the galactic disk which is thought to be an outcome of some ancient collision. In the TGD framework this structure would be associated with a cosmic string, which has in some places thickened to a flux tube and generated ordinary matter in this process.

Also the spiral arms might be accompanied by cosmic strings. In any case, there would be a long cosmic string orthogonal to the galactic plane (jets are parallel to it quite generally) having galaxies along it and generated by the thickening of the cosmic string generating blackhole-like entities as active galactic nuclei.

Just yesterday I learned that the Milky Way also offers other surprises (`https://cutt.ly/pQPpyJo`). One of them is that the galactic disk contains old stars that should not be there but in the outskirts of the galaxy which is the place for oldies whereas younger stars live active life in the galactic disk. This if one assumes that the usual view about the formation of galaxies is correct. This applies also to the weird filaments mentioned above.

In the TGD Universe, galaxies are not formed by a condensation of gas but by a process replacing inflaton decay with a process in which cosmic strings thicken and their string tension - energy density - is reduced [L14, L17, L26]. The liberated energy forms the ordinary matter giving rise to the galaxy. This solves the dark matter problem: strings define dark matter and energy and no halo is needed to produce a flat velocity spectrum of distant stars. The collisions of cosmic strings are unavoidable in 3-D space and could have induced the thickening process creating the active galactic nuclei (quasars).

This process would be opposite to what is believed to occur in the standard model. What comes to mind is that the oldies in the disk are formed from a cosmic string portion in the galactic plane. The tangle of the cosmic string can indeed extend in the galactic plane over long distances and there can also be cosmic strings (associated with galactic spiral arms?) in the galactic plane, which would have almost intersected a cosmic string orthogonal to the plane inducing the formation of the Milky Way.

4 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.

4.1 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 [L19]. 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.

4.2 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.

4.3 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.

4.4 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.

4.5 Support for TGD view about galactic dark matter

Cosmology an also other fields of physics with one exception - particle physics - produces fascinating results on daily basis. It is really a pity that particle physicists living in the jail of their reductionistic world view cannot pay any attention to these discoveries and continue moaning that there is no data so that it impossible to go beyond standard model. Bad philosophy can kill entire field of science. Having replaced Planck length scale reductionism by fractality I can enjoy swimming in the flood of anomalies.

One of the surprises was a popular article about a detection of dark matter lumps [E8] (http://tinyurl.com/vjvhyud) by Hubble telescope. The discovery is based on gravitational lense effect. The popular article tells about light coming distant quasars - distance is about 10 million light years. At the path of light coming to Earth there is foreground galaxy - distance is about 2 million light years. They are reported to give rise to four separate images of the galaxy by lense effect.

I am however wondering why one observes four images of each quasar by foreground galaxy. My naïve expectation would be a ring if dark matter halo gives rise to the lensing. If so the finding would represent an anomaly. It is also stated that the number of images depends on how many different dark matter particles there exists. I must admit that I do not understand.

What says TGD?

1. If galaxies are associated with long cosmic strings as tangles as in TGD Universe, flat velocity spectrum is automatically predicted without any other assumptions and velocity spectrum determines string tension [L14, L17]. (http://tgdtheory.fi/public_html/articles/meco.pdf and http://tgdtheory.fi/public_html/articles/galaxystars.pdf).

2. Long cosmic string would give rise to two separate images in lensing effect rather than ring as halo would do. Two long foreground cosmic strings with different directions - say being nearly orthogonal - would give rise to four images.

3. The two cosmic strings could be assigned with fusion of two galaxies associated with separate cosmic strings. One can consider the possibility that visible galaxies are formed as two cosmic strings collide: this would give rise to instability initiating the thickening of the 2-D M^4 projection of cosmic string and formation of tangles associated with both cosmic strings. Magnetic energy would be liberated and transform to ordinary matter giving rise to the visible matter of galaxy. For instance, could the 4 spiral arms of Milky way could relate to the second cosmic string in the plane of Milky way tangled around the second cosmic string orthogonal to the plane of Milky Way?

   One can consider also a situation in which there is no foreground galaxy but just two cosmic strings and this might provide a test for TGD view.

5 Cosmic spinning filaments that are too long

The inspiration for writing this article came from a highly interesting popular article (https://cutt.ly/inMODTT) providing new information about the cosmic filaments (thanks to Jebin Larosh for the link). The popular article tells about the article published in Nature [E14] (https://cutt.ly/HnMOGcP) and telling about the work of a team led by Noam Libeskind.

5.1 Findings

What has been studied is a long filament with length of order 10^8 ly characterizing the sizes of large cosmic voids. The filament consists of galaxies and the surprising finding is that besides moving along the filament, the galaxies associated with the filaments spin around the filament axis.

This finding suggests a network of filaments of length of order 10^8 ly and thickness of order 10^6 ly intersecting at nodes formed by large galaxy clusters. The larger the masses at the ends of the filament are, the larger the spin is.

How angular momentum is generated is the problem. The problem is quite general and is shared by both Newtonian and General Relativistic Universes. The natural assumption is that angular momentum vanishes in the original situation. Angular momentum conservation requires a generation of compensating angular momentum. This should happen in the case of all rotating structures. Already the case of galaxies is problematic but if the length scale of the structure is 10^8 ly, the situation becomes really difficult.

Gravitationally bound states have as a rule angular momentum preventing gravitational collapse but how the angular momentum is generated in a process believed to be a concentration of a homogeneous matter density to astrophysical objects? The basic problem is that the Newtonian description relies on scalar potential so that the field lines of the Newtonian gravitational field are never closed. It is difficult to imagine mechanisms for the generation of angular momentum by rotation. In the GRT based description gravi-magnetic fields, which are rotational, emerge but they are extremely weak. The proposal is that tidal forces could generate angular momentum but the generation of angular momentum remains poorly understood.

5.2 TGD view about the angular momentum generation

Could one understand the recent finding, and more generally, the generation of angular momentum, in the TGD framework? What raises hope is that in the TGD framework Kähler magnetic fields, whose flux tubes can be regarded as space-time quanta, are key players of dynamics in all scales besides gravitation.

5.2.1 Cosmic strings as carriers of dark matter and energy

The basic difference between GRT and TGD are cosmic strings and flux tubes resulting from their thickening. Cosmic strings are preferred extremals which are space-time surfaces with 2-D string world sheet as M^4 projection and complex surface of CP_2 as CP_2 projection.

1. The presence of the long filaments is one of the many pieces of support for the fractal web of cosmic strings thickened to flux tubes predicted by TGD. The scale is the scale of large voids 10^8 ly forming a kind of honeycomb like structure. The density of matter would be fractal in the TGD Universe [L14, L17] (http://tgdtheory.fi/public_html/articles/meco.pdf and http://tgdtheory.fi/public_html/articles/galaxystars.pdf).

2. Long cosmic string has a gravitational potential proportional to $1/\rho$, ρ the transverse distance. This predicts a flat velocity spectrum for the stars rotating around the galaxy. No dark matter halo is needed. The model contains only a single parameter, string tension, and also this can be understood in terms of the energy density of the cosmic string. The motion along the string is essentially free motion which allows to distinguish the model from the halo model. In fact, the article [E14] reports linear motion along the filament.

   Amusingly, the same day that I learned about the spinning filaments, I learned about a new evidence for the absence of the galactic halo from a popular article (https://cutt.ly/MnMOI7F telling about the article by Shen *et al* [E12] (https://cutt.ly/HnMOPNA).

5.2.2 Compensating angular moment as angular momentum of dark matter at cosmic string

Consider now the problem of how the compensating angular momentum is generated as visible matter starts to rotate.

In the TGD framework the picture is just the opposite.

1. The basic assumption of the Newtonian and GRT based models for the generation of angular momentum is that all astrophysical objects are formed by a condensation of matter along perturbations of the mass density. The flow of mass occurs from long scales to short scales.

2. Cosmic strings are the basic objects present already in primordial cosmology [K12, K6, K4]. Long cosmic strings form tangles along them in a local thickening, which gives rise to flux tubes [L14, L17, L20]. This involves the decay of dark energy and matter at cosmic string to ordinary matter around them as the string tension is reduced in a phase transition decreasing the coefficient of the volume term present in the action besides Kähler action as predicted by twistor lift of TGD [K10, K13]. This parameter corresponds to length scale dependent cosmological constant Λ.

   Λ depends on p-adic length scale $L_p \propto \sqrt{p}$, $p \simeq 2^k$ and satisfies $\Lambda(k) \propto 1/L^2(k)^2$. $\Lambda(k)$ approaches zero in long p-adic length scales characterizing the transversal size of flux tubes. This solves the cosmological constant problem. The thickness $d \sim L(k)$ of the flux tube, which is rather small, determines the string tension. To $L(k)$ there is associated a long p-adic length scale which is of order size of observed cosmology if $d \sim L(k)$ is of order of 10^{-4} meters, which happens to be the size of a large neuron.

3. The phase transitions reducing Λ reduce string tension are analogous to the decay of the inflaton field vacuum energy to ordinary matter. Now inflaton field vacuum energy is replaced with the dark energy and matter associated with the thickening cosmic string. Each phase transition is accompanied by an accelerated expansion. The period known as inflation in stanaard cosmology is the first phase transition of this kind. The recent accelerated expansion would correspond to a particular period of this kind and will eventually slow down.

What could happen in the decay of the energy of a flux tube tangle of a cosmic string to visible matter?

1. The visible matter resulting in the decay of the cosmic string must start to rotate around the cosmic string since otherwise it would fall back to the cosmic string like matter into a blackhole. The cosmic string must somehow generate a spin compensating the angular momentum of the visible matter.

2. One should understand angular momentum conservation. Generation of visible matter with angular momentum is possible only if the dark cosmic string is helical or becomes (increasingly) helical in the phase transitions. The angular momentum would be accompanied by the longitudinal motion along the string: this motion has been observed for the filaments [E14] .

   The helical structure could be present from the beginning or be generated during the decay of energy of the cosmic string leading to the local thickenings to flux tube giving rise to galaxies as tangles along a long cosmic string. Also the dark matter and energy at the cosmic string already have angular momentum so that the dark matter that transforms to visible matter would inherit this angular momentum.

   The reported correlation between the masses at the ends of the filament and the spin of the filament [E14] could be understood if the masses at the ends are formed from the dark energy and mass of the filament having angular momentum. The amount of spin and mass at the ends would be the larger, the longer the decay process has lasted.

3. The identification of the galaxies as tangles along long cosmic strings explains the flatness of the galactic velocity spectrum. Galaxy rotates and also now the angular momentum conservation is the problem. The simplest solution is that the cosmic string portions between the tangles generate the angular momentum opposite to that of the visible matter.

This would happen not only for the portions of cosmic string between galaxies but also those between stars in the galactic tangle. Stars would be flux tube spaghettis and the angular momentum of the star would be compensated by the angular momentum associated with the helical cosmic string continuing outside the star and connecting it to other stars.

The illustration of the popular article brings in mind a DNA double strand and inspires a consideration of an alternative, perhaps unnecessarily complex, model.

1. Suppose one has a double helix of cosmic strings, call them Alice and Bob. Two stellar objects can form a gravitationally stable state only if relative rotation is present. This would be true also for a cosmic double strand to prevent gravitational collapse in 2-D sense.

2. Alice could remain a cosmic string and thus dark so that we would not see it. Bob would thicken to a flux tube and produce ordinary matter as galaxies as ordinary matter realized tangles along it. The matter would inherit the angular momentum the dark matter and energy producing it already has. The string tension of Bob would be reduced in this process. Of course, both Alice and Bob could have tangles along them. The experiments however support the view that spin direction is the same along the filament.

3. If the helical pair of cosmic strings is actually a closed loop in which the second strand is a piece of the same string, the motion of matter along strands is automatically in opposite directions and spins are opposite. The rotational motion as a stabilizer of a gravitationally bound state is transformed to a helical motion. The problem is however why only the other strand decays to ordinary matter (in the case of ordinary DNA there is an analogous problem due to the passivity of the second strand).

5.2.3 Is quantum gravitation cosmic scales involved?

There is an interesting connection to atomic physics suggesting that quantum effects are associated with gravitationally bound dark matter even in astrophysical scales.

1. The basic problem was that the electron should radiate its energy and fall into the atomic nucleus. The Bohr model of the atom solved the problem and non-radiating stationary states prevented the infrared catastrophe. Also in the gravitational case something similar is expected to happen for gravitational interaction.

2. The Bohr model of solar system [K11, K1], originally introduced by Nottale [E4], relies on the notion of gravitational Planck constant $hbar_{gr} = GMm/\beta_0$ predicts angular momentum quantization [L13, L24].

3. Angular momentum quantization as multiples of $\hbar_{gr}$ could occur also for the matter rotating around the cosmic string. In the case of the filament, the mass M could be replaced with the mass of the cosmic string (or possibly several of parallel cosmic strings) and m could correspond to the mass of a galaxy rotating around it. The velocity parameter $\beta_0 = v_0/c$ has a spectrum of values [L24] proposed to come as inverse integers.

6 A solution of two galactic anomalies in the TGD framework

Two anomalies related to the physics of galaxies are discussed. The first strange finding is that the initial mass function of galaxies depends on distance from the observer [E13]. The newest anomaly of cold dark matter models is that the stars of the satellite galaxies of bigger galaxies tend to rotate around the host galaxy in planar orbits rather than along random orbits as halo models predict.

6.1 Can the initial mass function of galaxies really depend on distance from the observer?

In learned about new very interesting findings related to distant galaxies from a popular article "*New discovery about distant galaxies: Stars are heavier than we thought*" (see `https://cutt.ly/UJdEG2G`. The article tells of the work done by astrophysicists in Niels Bohr Institute, Denmark by A. Sneppen et al.

The article "*Implications of a Temperature-dependent Initial Mass Function. I. Photometric Template Fitting*" [E13] provides a technical description of the work (`https://cutt.ly/SJdEZik`). The abstract of the article gives an overall view of the findings.

> *A universal stellar initial mass function (IMF) should not be expected from theoretical models of star formation, but little conclusive observational evidence for a variable IMF has been uncovered. In this paper, a parameterization of the IMF is introduced into photometric template fitting of the COSMOS2015 catalog. The resulting best-fit templates suggest systematic variations in the IMF, with most galaxies exhibiting top-heavier stellar populations than in the Milky Way. At fixed redshift, only a small range of IMFs are found, with the typical IMF becoming progressively top-heavier with increasing redshift. Additionally, subpopulations of ULIRGs, quiescent and star-forming galaxies are compared with predictions of stellar population feedback and show clear qualitative similarities to the evolution of dust temperatures.*

Here is how I understand the basic notions and reported findings appearing in the article.

1. Initial mass function IMF used in the modelling of the galaxies is the key notion. IMF would be the initial distribution of stellar masses as galaxy started to evolve. The ages of galaxies between 10-13.6 billion years so that they formed very early. It would be very natural to assume that IMF is universal and same for all galaxies, and this has been indeed done. The candidate for a universal IMF has been determined from the data related to Milky Way and its satellites. There are however several candidates for the galactic IMF.

2. The finding of the group is that IMF is not universal and tends to concentrate towards higher masses for distant and therefore younger galaxies. The proposed IMF is parametrized by using a temperature like parameter T_{IMF}, interpretable as the temperature when the galaxy was formed.

   Here I however encounter a problem in my attempts to understand. I find it difficult to comprehend why T_{IMF}, a parameter that should characterize a galaxy, should depend on the distance of this galaxy from us. This looks nonsensical. Perhaps IMF is not what "initial mass function" suggests. What does one mean with "initial"? Or maybe some very interesting new physics related to the notion of time and aging of the stars is lurking there!

3. High mass stars have a short lifetime and end up to Supernovae unless the star formation creates new ones. Because stellar mass is dominated by low-mass stars, the inferred stellar masses and star formation rates (SFRs) are highly sensitive to the ratio of high-mass to low-mass stars in the IMF. The inferred extinction, metallicity, and other properties depend on the assumed IMF.

   In the standard model, star formation is sensitive to the pressure-gravitation balance. The IMF should be sensitive to all variables that can affect it. Article mentions central gravitational potential, existing stellar mass, star formation history, supernova rate, cosmic-ray density and galactic magnetic fields, metallicity, dust density and composition, AGN activity, and the environment and merger history.

   All of these are known to vary both between different galaxies at fixed redshift and across different redshifts. According to the authors, it should be expected that the IMF is not universal but rather differs between galaxies and between different epochs for the same galaxy. In particular, the IMF should depend upon the gas temperature of star-forming clouds, with higher-temperature regions producing higher average stellar masses. Because observations of dust even at moderate redshifts find an increase in temperature toward higher redshifts.

4. Authors notice that already in the case of the Milky Way there are several candidates for IMB and that typical stellar mass and star formation rate (SFR) are highly sensitive to IMF. There are also significant degeneracies between the IMF and extinction, metallicity, star formation history, and the age of the stellar population, which makes it very difficult to determine the entire shape of IMF.

5. The group performs a fit to a temperature dependent family of IMFs having initial temperature T_{IMF} as a parameter. What is nice is that for a given redshift, this is found to give only a few candidates for the IMF. The very distant galaxies would be top-heavier (stellar mass would be concentrated towards higher masses) and the fraction of heavier stars would be higher.

The proposal of the authors can be criticized. There is no doubt that the dependence of IMF on the galaxy is a fact but its dependence on the distance of the galaxy from us is in a glaring conflict with the standard view about time evolution, in particular with the basic assumption of the standard ontology stating that our geometric past is fixed.

Initial mass function (IMF) would be the initial distribution of stellar masses as the galaxy started to evolve about 10-13.6 billion years ago. It would be very natural to assume that the IMF is universal and the same for all galaxies, and this has indeed been done. The candidate for a universal IMF has been determined from the data related to the Milky Way and its satellites. There are several candidates for the galactic IMF. It has been however found that the IMF depends on the distance of the galaxy from Earth and that the IMFs tend to concentrate on larger stellar masses. The dependence of MF on this distance is in conflict with the standard view about time assuming that the geometric past is fixed.

Zero energy ontology (ZEO) [L21, L25, L27] [K14] defines the ontology behind TGD based quantum measurement theory and solves the basic paradox of quantum measurement theory. Second key element is the predicted hierarchy of effective Planck constants [L8] labeling phase of ordinary matter behaving like dark matter.

ZEO suggests a solution to the paradox created by the findings. TGD Universe is quantum coherent also in astrophysical scales and "big" state function reductions (BSFRs) reversing the arrow of time opposite to that for the environment occur for stars making them blackholes. This is the case also in GRT for Kerr-Newman rotating blackholes. Also quasars as white holes transform in BSFR to galactic blackholes with an arrow of time opposite to that for a distant environment. ZEO implies that the geometric past and thus the IMF of the galaxy changes in the sequence of BSFRs. A simple argument based on the fact that massive stars are shorter-lived shows that the IMF for large distances from Earth indeed is concentrated on larger stellar masses.

6.2 The satellite plane anomaly of the cold dark matter model

The anomalies of the halo models of galactic matter have been steadily accumulating during years. For instance, it has been found that satellite galaxies of larger galaxies tend to move in planes [E17] whereas the ΛCDM predicts that the orbits are more or less random. Quite generally, ΛCDM fails on short scales.

The TGD based solution of the satellite galaxy problem relies on the TGD view about galactic dark matter: dark energy and dark matter reside at long cosmic strings, which can form tangles at which the flux tubes thicken and liberate energy forming the ordinary galactic matter. The orbits of the stars around the cosmic string are helical orbits in a plane orthogonal to the string and, as a special case, planar orbits. The velocity curve is flat without further assumptions. The preferred planes could correspond to planar minimal surfaces with 3-D E^3 projection.

6.3 TGD based explanation for the dependence of IMF on distance

What could be the TGD based interpretation of the strange findings? Could the cosmic string model for the formation of galaxies and stars [L14, L17, L26] predict the time evolution of the galactic mass distribution by assuming a universal IMF? The paradoxical finding challenges the standard view about time: could zero energy ontology (ZEO) [L21, L25, L27] implying radical revision of this notion, be involved in an essential manner?

6.3.1 Cosmic string model for the formation of astrophysical objects

Consider first the cosmic string model for the formation of galaxies, stars, planets and and also smaller objects [?]

1. Cosmic strings would be the fundamental objects. Their string tension is determined by CP_2 length scale determining their energy density identifiable as dark energy and Kähler magnetic energy. Also ordinary and dark particles in the TGD sense can contribute to the density of energy. Galaxies are assumed to be tangles of a long cosmic string at which the cosmic string has thickened to a monopole flux tube with reduced string tension. The flat velocity spectrum of stars rotating around the cosmic string is flat and the value of the velocity is dictated by the string tension. Therefore galactic dark matter as a halo is replaced with the energy density of the long cosmic string containing galaxies as its tangles: this explains the linear structure formed by galaxies.

2. The energy of the cosmic strings would have been liberated as ordinary matter: this is completely analogous to the formation of ordinary matter in the decay of the inflaton field in inflation models. The seeds of stars can be identified as sub-tangles of galactic flux tubes analogous to spaghettis. This hierarchy of tangles inside tangeles inside... tangles continues to short length scales, even biomolecules, atomic nuclei, and hadrons would be this kind of tangles. The already existing ordinary matter could condense around these seeds.

   The conservative guess is that this analog of inflation was significant only during the very early stages of star formation when no stars existed yet and only the transformation of dark energy to ordinary matter could give rise to stars.

   The flux tube tangle would thicken and generate stellar objects as subtangles. The farther the star is, the younger the galaxy is. Massive stars as supernovas die soon and the mass function shifts to lighter stellar masses.

3. New massive stars are not formed after the galactic cosmic string tangle and galactic blackhole-like entity reaches a maximal size: one could say that the galaxy dies. After this star formation could happen as a condensation process around tangles serving as seeds as in the standard model and would give rise to stars, planets, and even smaller objects. The development of the flux tube containing the tangles would determine galactic evolution.

4. Note that a quasar identified as a galactic blackhole-like object would be there from the beginning and feed mass to its environment. In the spirit of ZEO, I have proposed that it is the TGD analog of white hole and a time reversed version of a blackhole-like object. Instead of sucking matter inside it it would spew matter outside, essentially energy of cosmic string, out which gives rise to the galactic matter.

   BSFR means death in a universal sense and in a well-defined sense, a blackhole is a dead object. Could blackhole be a time reversal of a white hole as quasar. BSFR changes the arrow of time and the radiation produced by blackhole would travel to the geometric past: nothing would come out from the perspective of the observer in the future! This what ordinary blackholes indeed look like. Could blackhole-like entities have an arrow of time, which is opposite to that of the environment? As a matter of fact, this would not be new! Also in GRT, Kerr-Newman solutions representing rotating blackholes have an arrow of time opposite to that of a distant environment [?]. I have discussed Kerr-Newman blackholes in the appendix of [K5].

   Both galactic blackholes and stellar blackholes would be dead and time reversed quasars and "live" in a reversed time direction. Also ordinary blackholes would "live" in the opposite direction of time.

6.3.2 The interpretation of IMF and T_{IMF} in the TGD framework

What could be the interpretation of the IMF in the TGD framework? Does the parameter T_{IMF} appear naturally? Since the formation of galaxies and stars would be a process analogous to inflation, it would seem that the gravitational condensation around seeds defined by the flux tube tangles dominates except in very early times. Hence it would seem that the interpretation in terms of IMF which depends on T_{IMF} must make sense in the TGD framework. This is not possible without a new view about time provided by zero energy ontology (ZEO).

1. Zero energy ontology (ZEO) [L21, L25, L27] suggests a radical interpretation for the dependence of IMF on the distance of the galaxy from us. In ZEO, the stars of the galaxy evolve by state function reductions (SFRs) occurring in stellar and even longer scales. This is due to the hierarchy of effective Planck constants predicted by number theoretical vision of TGD involving the notion of $M^8 - H$ duality [L22, L23]) and adelic physics [L8]. ZEO predicts that both "big" and "small" SFRs (BSFRs and SSFRs) are possible.

2. In the BSFR, the arrow of geometric time changes and BSFRS can change even in astrophysical scales. This could explain the observation of stars which are older than the Universe [L17]. A given star would make BSFRs and in this manner evolve forth and back in the geometric time and become physically older but the center of mass time coordinate for the causal diamond (CD) of the star would not shift to the geometric future so that aging as it is usually understood would not take place.

   The size L of the CD is expected to increase in the process and could define as its inverse a parameter analogous to $T_{IMF} = \hbar_{eff}/L$.

3. The stellar BSFRs could explain the nonsensical looking dependence of the IMF on the distance of the galaxy from us. These stars of these very old galaxies would experienced would have made a large number of BSFRs. By universal evolution [L8] they would be at a high evolutionary stage and can be said to be represent old stars, stars older than the Universe. Star would have transformed to a blackhole and back to a white hole serving as a seed for the formation of a new star. The massive stars would have disappeared as supernovas and the mass distribution of these stars defining the IMF would shift towards lighter masses. Also the temperature would decrease for these stars determining IMF, which would imply the paradoxical looking decrease of T_{IMF} with the increasing cosmic distance.

6.4 TGD based explanation of the satellite plane anomaly of the cold dark matter model

The satellite galaxies of larger galaxies tend to move in a plane around the host as described in the review article [E17] whereas the ΛCDM predicts that the orbits are more or less random. The article gives illustrations showing the concentration around the planes for the Milky Way, Andromeda, and Centaurian. The plane of satellites is approximately orthogonal to the plane of the host galaxy in all cases.

Quite generally, ΛCDM fails on short scales. The success in long scales is understandable in the TGD framework since the approximation of the mass density of cosmic strings by a continuous mass density is good in long scales.

6.4.1 Why planar orbits are preferred?

TGD predicts [L14, L17, L26] a fractal network of very massive long cosmic strings which can locally thicken to flux tubes: this thickening involves transformation of dark energy and possible dark matter of cosmic string to ordinary matter giving rise to galaxies and other structures. Also stars would have thickened flux tube tangles inside themselves. The model finds support from the observation that galaxies form long strings as found decades ago (Zeldowich was one of the discoverers [E22]).

The TGD based model predicts the formation of planes in which objects in various scales move. The prediction is fractal: this applies to planets around stars, stars around galaxies, satellite galaxies around larger galaxies,....

This model explains the satellite plane anomaly and also the earlier anomalies if the galaxies are associated with the long "cosmic strings" predicted by TGD [K4]. They create a strong gravitational potential giving rise to a radial force in the plane orthogonal to the cosmic string. The motion along the string is free whereas the planar motion is rotation. The velocity spectrum is flat as required by the flatness of the galactic velocity spectrum. In the simplest model cosmic string is the carrier of galactic dark matter and dark energy. No dark matter halo and no exotic dark matter particles are needed.

Helical orbits are the most general orbits. If a concentration of matter occurs to a plane, it tends to catch objects moving freely in the direction of string to its vertical gravitational field and planar sheets such planetary systems, spiral galaxies, and the planar systems formed by satellite galaxies can form.

The first guess is that the satellite galaxies move in the plane of the host galaxy. The plane is however approximately orthogonal to the plane of the host in the 3 cases illustrated in [E17].

1. I have proposed that the intersections of nearly orthogonal cosmic strings could induce the thickening to flux tubes and transformation of the dark energy of flux tubes to ordinary matter starting to rotate in the planes defined by the intersecting cosmic string.

2. These intersections are unavoidable for strings like objects in 4-D space-time and would occur at discrete points. In the collision of cosmic strings, these points would define the nucleus of the host galaxy, say the Milky Way. The satellite galaxies would be assignable to the plane defined by the second colliding cosmic string, which would take the role of stars in the plane of the host galaxy.

   The colling cosmic strings would be in a very asymmetric position. Why this asymmetry? Could the satellites correspond to circular pieces of cosmic string generated in the collision by reconnections (note the analogy with reconnections of magnetic flux tubes of solar wind occurring during auroras) and generating the matter of the satellite.

   Why only the second cosmic string would have satellites around it? For two separate cosmic strings it is difficult to understand why reconnection would form loops. This process is natural for the two antiparallel strands of a closed U-shaped loop. Cosmic strings indeed form loops.

This model involves two strings. One can also consider a single cosmic string.

1. Cosmic strings are closed in a large enough scale, and the model for quantum biology encourages to consider U-shaped cosmic strings for which the parallel string portions carry opposite magnetic fluxes and can naturally reconnect. The flux tube could self-reconnect and generate loops, possibly assignable to the satellite galaxies. The reconnection process would be fundamental in TGD inspired quantum biology (see for instance [L28]).

2. In the reconnection of the strands carrying opposite magnetic flux would form a section S orthogonal to the long part L of the U-shaped string. Could one assign the host galaxy with L and the satellite galaxies to S? L and S would define nearly orthogonal planes and the satellite galaxies could form around loops created from L by a repeated reconnection and they would rotate around the host in the plane defined by S.

Evidence for the failure of the dark halo model has been steadily accumulating during years. The popular article "New Discovery Indicates an Alternative Gravity Theory" published in SciTechDaily (`https://cutt.ly/dBVUBUn`) tells of the most recent discovery challenging the halo model. The dwarf galaxies of one of Earth's closest galaxy clusters do not behave as the halo model predicts.

Elena Asencio, a Ph.D. student at the University of Bonn was the lead author of the article *"The distribution and morphologies of Fornax Cluster dwarf galaxies suggest they lack dark matter* published in Monthly Notices of the Royal Astronomical Society [E5] (`https://cutt.ly/wNPRLI5`).

The following gives the abstract of the article in shortened form.

Due to their low surface brightness, dwarf galaxies are particularly susceptible to tidal forces. The expected degree of disturbance depends on the assumed gravity law and whether they have a dominant dark halo. This makes dwarf galaxies useful for testing different gravity models.

1. Tidal susceptibility η (half-mass radius divided by theoretical tidal radius) is the basic notion. Below a certain critical value η_{destr}, tidal forces destroy the dwarf galaxy.

2. The properties of dwarf galaxies in the Fornax Cluster were compared with those predicted by the Lambda cold dark matter (ΛCDM) standard model of cosmology and Milgromian dynamics (MOND). A test particle simulation of the Fornax system was constructed. The Markov Chain Monte Carlo (MCMC) method was used to fit this to the FDS distribution of η, the fraction of dwarfs that visually appear disturbed as a function of η, and the distribution of projected separation from the cluster centre.

3. It was possible to constrain the η value at which dwarfs should get destroyed by tides. Accounting for an r'-band surface brightness limit of 27.8 magnitudes per square arcsec, the required stability threshold is $\eta_{destr} = 0.25 + 0.07 - 0.03$ in ΛCDM. This value is in tension with previous N-body dwarf galaxy simulations, which indicate that $\eta_{destr} \sim 1$.

4. The MOND N-body simulations indicated $\eta_{destr} = 1.70 \pm 0.30$, which agreed well with the MCMC analysis of the FDS. The conclusion was that the observed deformations of dwarf galaxies in the Fornax Cluster and the lack of low surface brightness dwarfs towards its centre are incompatible with ΛCDM expectations but well consistent with MOND. In accordance with findings, the observed half mass radii tend to be larger in MOND than in ΛCDM dynamics.

The dwarfs are more sensitive to the effects of the tidal forces in the MOND dynamics than in ΛCDM dynamics because the dark matter halo surrounding the dwarf galaxy and acting like a mattress, would shield it from the tidal forces. The observed tidal forces are too large to be consistent with the presence of the dark matter halo.

In the TGD framework [L14, L17, L26], the dark matter halo is replaced with a long cosmic string whose energy density giving rise to dark energy explains also the flat velocity spectrum of galaxies. There is no shielding.

6.4.2 Is there something that could define galactic planes?

One can wonder whether there is something, which serves as a seed for the concentration of stars around a selected plane, perhaps associated with the boundary of a cell of the honeycomb structure. The collision of two cosmic strings would naturally define two planes of this kind. In the case of a single U-shaped closed string, which looks a more promising option, there is no obvious identification of the plane orthogonal to this object.

1. In the TGD Universe, space-time is a 4-surface in $H = M^4 \times CP_2$ and also membrane like entities are predicted as 4-D minimal surfaces of H having lower-D singularities analogous to the frames of a soap film minimal surface property (and simultaneous extermality with respect to Kähler action) fail but the field equations for the entire action involving volume term and Kähler action are satisfied at the singularities.

2. One can also consider 3-D singularities, which form a tessellation of H^3 at a given moment of cosmic time a and assign it with the honeycomb of large voids. The frame would be a tessellation. The quantization of cosmic redshifts in a given direction, discussed from the TGD viewpoint in [K12], could be seen as evidence for cosmic tessellations having astrophysical objects at their nodes.

   The boundaries of the large cosmic voids form a honeycomb structure and could correspond to a tessellation of H^3. The long U-shaped cosmic strings would be associated with the boundaries of the cells of the honeycomb and perhaps even form a 2-D lattice like structure.

   TGD suggests [L14, L17, L26] a fractal network of very massive long cosmic strings which can locally thicken to flux tubes: this thickening involves transformation of dark energy and possible dark matter of cosmic string to ordinary matter giving rise to galaxies and other structures. Also stars would have thickened flux tube tangles inside themselves. The model finds support from the observation that galaxies form long strings as found decades ago (Zeldowich was one of the discoverers [E22]).

3. The objects $M^1 \times X^2 \times S^1$, where M^1 is time axis, X^2 is a piece of plane of E^2, and S^1 is a geodesic sphere of CP_2, define very simple minimal surfaces carrying no induced Kähler

field. The objects X^2
$times S^1$ could accompany the boundaries of the honeycomb cells. Universe could be populated by these membrane-like objects. Cell membrane is one important example.

4. Planar or approximately planar objects orthogonal to the cosmic string could tend to gather the matter flowing along helical orbits along the cosmic string. These planes would accompany planetary, galactic, etc... planes and the honeycomb structure could be also seen as a fractal analog of a multicellular structure.

5. Warped planes represent slightly more complex minimal surfaces with 3-D M^4 projection (a thin metal foil or sheet of paper gets warped) for which the plane is deformed but still flat minimal surface. I am not sure whether the "warping" [E1] (`https://cutt.ly/dHoeZKw`) of the outer regions of galactic planes, which has received attention recently (`https://cutt.ly/pHorgcD` and) but has been detected already 1956, is really really warping that is vertical deformation, which depends only single coordinate varying along a straight line (a 2-D plane wave of membrane).

7 Can the initial stellar mass distribution of galaxy really depend on its distance from Earth?

In learned about new very interesting findings related to distant galaxies from a popular article "*New discovery about distant galaxies: Stars are heavier than we thought*" (see `https://cutt.ly/UJdEG2G`. The article tells of the work done by astrophysicists in Niels Bohr Institute, Denmark by A. Sneppen et al.

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Here is how I understand the basic notions and reported findings appearing in the article.

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2. The finding of the group is that IMF is not universal and tends to concentrate towards higher masses for distant and therefore younger galaxies. The proposed IMF is parametrized by using a temperature like parameter T_{IMF}, interpretable as the temperature when the galaxy was formed.

   Here I however encounter a problem in my attempts to understand. I find it difficult to comprehend why T_{IMF}, a parameter that should characterize a galaxy, should depend on the distance of this galaxy from us. This looks nonsensical. Perhaps IMF is not what "initial mass function" suggests. What does one mean with "initial"? Or maybe some very interesting new physics related to the notion of time and aging of the stars is lurking there!

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2. The energy of the cosmic strings would have been liberated as ordinary matter: this is completely analogous to the formation of ordinary matter in the decay of the inflaton field in inflation models. The seeds of stars can be identified as sub-tangles of galactic flux tubes analogous to spaghettis. This hierarchy of tangles inside tangeles inside... tangles continues to short length scales, even biomolecules, atomic nuclei, and hadrons would be this kind of tangles. The already existing ordinary matter could condense around these seeds.

   The conservative guess is that this analog of inflation was significant only during the very early stages of star formation when no stars existed yet and only the transformation of dark energy to ordinary matter could give rise to stars.

   The flux tube tangle would thicken and generate stellar objects as subtangles. The farther the star is, the younger the galaxy is. Massive stars as supernovas die soon and the mass function shifts to lighter stellar masses.

3. New massive stars are not formed after the galactic cosmic string tangle and galactic blackhole-like entity reaches a maximal size: one could say that the galaxy dies. After this star formation could happen as a condensation process around tangles serving as seeds as in the standard model and would give rise to stars, planets, and even smaller objects. The development of the flux tube containing the tangles would determine galactic evolution.

4. Note that a quasar identified as a galactic blackhole-like object would be there from the beginning and feed mass to its environment. In the spirit of ZEO, I have proposed that it is the TGD analog of white hole and a time reversed version of a blackhole-like object. Instead of sucking matter inside it it would spew matter outside, essentially energy of cosmic string, out which gives rise to the galactic matter.

   BSFR means death in a universal sense and in a well-defined sense, a blackhole is a dead object. Could blackhole be a time reversal of a white hole as quasar. BSFR changes the arrow of time and the radiation produced by blackhole would travel to the geometric past: nothing would come out from the perspective of the observer in the future! This what ordinary blackholes indeed look like. Could blackhole-like entities have an arrow of time, which is opposite to that of the environment? As a matter of fact, this would not be new! Also in GRT, Kerr-Newman solutions representing rotating blackholes have an arrow of time opposite to that of a distant environment [?]. I have discussed Kerr-Newman blackholes in the appendix of [K5].

   Both galactic blackholes and stellar blackholes would be dead and time reversed quasars and "live" in a reversed time direction. Also ordinary blackholes would live in the opposite direction of time.

7.1.2 The interpretation of IMF and T_{IMF} in the TGD framework

What could be the interpretation of the IMF in the TGD framework? Does the parameter T_{IMF} appear naturally? Since the formation of galaxies and stars would be a process analogous to inflation, it would seem that the gravitational condensation around seeds defined by the flux tube tangles dominates except in very early times. Hence it would seem that the interpretation in terms of IMF which depends on T_{IMF} must make sense in the TGD framework. This is not possible without a new view about time provided by zero energy ontology (ZEO).

1. Zero energy ontology (ZEO) [L21, L25, L27] suggests a radical interpretation for the dependence of IMF on the distance of the galaxy from us. In ZEO, the stars of the galaxy evolve by state function reductions (SFRs) occurring in stellar and even longer scales. This is due to the hierarchy of effective Planck constants predicted by number theoretical vision of TGD involving the notion of $M^8 - H$ duality [L22, L23]) and adelic physics [L8]. ZEO predicts that both "big" and "small" SFRs (BSFRs and SSFRs) are possible.

2. In the BSFR, the arrow of geometric time changes and BSFRS can change even in astrophysical scales. This could explain the observation of stars which are older than the Universe [L17]. A given star would make BSFRs and in this manner evolve forth and back in the geometric time and become physically older but the center of mass time coordinate for the causal diamond (CD) of the star would not shift to the geometric future so that aging as it is usually understood would not take place.

   The size L of the CD is expected to increase in the process and could define as its inverse a parameter analogous to $T_{IMF} = \hbar_{eff}/L$.

3. The stellar BSFRs could explain the nonsensical looking dependence of the IMF on the distance of the galaxy from us. These stars of these very old galaxies would experienced would have made a large number of BSFRs. By universal evolution [L8] they would be at a high evolutionary stage and can be said to be repret old stars, stars older than the Universe. Star would have transformed to a blackhole and back to a white hole serving as a seed for the formation of a new star. The massive stars would have disappeared as supernovas and the mass distribution of these stars defining the IMF would shift towards lighter masses. Also the temperature would decrease for these stars determining IMF, which would imply the paradoxical looking decrease of T_{IMF} with the increasing cosmic distance.

The newest anomaly of the cold dark matter model (ΛCDM) is discussed popular article "Space Has Invisible Walls Created by Mysterious 'Symmetrons,' Scientists Propose" (https://cutt.ly/mHorkqG). It has been found that satellite galaxies of larger galaxies tend to move in planes whereas the ΛCDM predicts that the orbits are more or less random. Quite generally, ΛCDM fails in short scales. The proposed model is involves traditional kind of new physics: a new exotic particle and symmetry breaking producing galactic plane domain walls.

TGD predicts [L14, L17, L26] a fractal network of very massive long cosmic strings which can locally thicken to flux tubes: this thickening involves transformation of dark energy and possible dark matter of cosmic string to ordinary matter giving rise to galaxies and other structures. Also stars would have thickened flux tube tangles inside themselves. The model finds supports from the observation that galaxies form long strings as found decades ago (Zeldowich was one of the discoverers [E22]).

The TGD based model predicts the formation of planes in which objects in various scales move. The prediction is fractal: this applies to planets around stars, stars around galaxies, satellite galaxies arond larger galaxies,....

This model explains the newest anomaly and also the earlier anomalies if the galaxies are associated with the long "cosmic strings" predicted by TGD [K4]. They create a strong gravitational potential giving rise to a radial force in the plane orthogonal to the cosmic string. The motion along the string is free whereas the planar motion is rotation. The velocity spectrum is flat as required by the flatness of the galactic velocity spectrum. In the simplest model cosmic string is the carrier of galactic dark matter and dark energy. No dark matter halo and no exotic dark matter particles are needed.

Helical orbits are the most general orbits. If a concentration of matter occurs to a plane, it tends to catch objects moving freely in the direction of string to its vertical gravitational field and planar sheets such planetary systems, spiral galaxies, and the planar systems formed by satellite galaxies can form.

One can of course wonder whether there is something which serves as a seed for the concentration of stars around particular plane. In TGD, space-time is a 4-surface in $H = M^4 \times CP_2$ and also membrane like entities are predicted as 4-D minimal surfaces in H. For instance, objects $M^1 \times X^2 \times S^1$ are predicted, where M^1 is time axis, X^2 is a piece of plane of E^2, and S^1 is a geodesic sphere of CP$_2$.$Universecouldbepopulatedbythesemembrane-likeobjects.Cellmembraneisoneimportantexample.Theseplan$

Warped planes represent slightly more complex solutions (a thin metal foil or sheet of paper gets warped) for which the plane is deformed but still flat minimal surface. I am not sure whether the "warping" (https://cutt.ly/dHoeZKw) of the outer regions of galactic planes, which has received attention recently (https://cutt.ly/pHorgcD and) but has been detected already 1956, is really really warping that is vertical deformation, which depends only single coordinate varying along a straight line (a 2-D plane wave of membrane).

8 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 naïve 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.

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