**Article**

# Breaking of $CP$, $P$, & $T$ in Cosmological Scales in TGD Universe

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**Abstract**

The twistor lift of TGD forces the analog of Kähler form for $M^4$. Covariantly constant sef-dual Kähler form $J(CD)$ depends on causal diamond of $M^4$ and defines rest frame and spin quantization axis. This implies a violation of $CP$, $P$, and $T$. By introducing a moduli space for the Kähler forms one avoids the loss of Poincare invariance. The natural question is whether $J(CD)$ could relate to CP breaking for K and B type mesons, to matter antimatter asymmetry and the large scale parity breaking suggested by CMB data. The simplest guess for the coupling strength of $U(1)$ interaction associated with $J(CD)$ predicts a correct order of magnitude for CP violation for K meson and for the antimatter asymmetry and inspires a more detailed discussion. A general mechanism for the generation of matter asymmetry is proposed, and a model for the formation of disk- and elliptic galaxies is considered. The matter antimatter asymmetry would be apparent in the sense that the CP asymmetry would force matter-antimatter separation: antimatter would reside as dark matter (in TGD sense) inside magnetic flux tubes and matter outside them. Also the angular momenta of dark matter and matter would compensate each other.

# 1 Introduction

The discovery of so called Axis of Evil (AE) in the spectrum of fluctuations for the cosmic microwave background (CMB) implies that the fluctuation spectrum is not isotropic. A possible explanation of AE could be large scale rotation - even the rotation of the Universe has been considered. Preferred direction of rotation in large scales requires cosmic $P$ violation. Standard model allows only a very slow rotation rate of the Universe and inflation theory does not allow rotation at all in large scales since the exponential expansion destroys the rotation very efficiently.

The idea of rotating Universe is not new. Already Gamow wrote about rotating Universe [6]. The idea was that the rotation of stellar objects is caused by the rotation of the Universe. If so, then rotation of the Universe could be observed.

Gödel in turn constructed a solution of Einstein's equations representing rotating Universe [9] as a birthday present to his friend Einstein. The solution allows closed time like geodesics so that the arrows of time are opposite near origin and at large distances. This can be seen as a problem. Also Kerr solution describing rotating black hole has similar problem.

Rotation has been observed long time ago in galactic scales and the angular momentum $J$ as a function of mass $M$ satisfies a correlation of form $J = kM^{5/3}$, $k = .4 \times 10^4\ \mathrm{kg}^{-2/3}\mathrm{m}^2\mathrm{s}^{-1}$ [1]. For string like objects one would have formula of form $J = kM^2$. The resemblance inspires the question whether the galaxies could have originated from string like objects and some of the angular momentum would have been lost in the process. This correlation is also satisfied by many other celestial objects. There is also evidence that the spin directions of galaxies correlate. The relative difference $(N_L - N_R)/(N_L + N_R)$ for numbers of right and left-handed spins (opposite for Northern and Southern Earth hemispheres is found to be about 7 per cent [12].

What could TGD say about large scale rotation.

1. The twistor lift of TGD forces he analog of Kähler form for $M^4$. Covariantly constant sef-dual Kähler form $J(CD)$ depends on causal diamond of $M^4$ and defines rest frame and spin quantization

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axis. This implies a violation of $CP$, $P$, and $T$. By introducing a moduli space for the Kähler forms one avoids the loss of Poincare invariance. The natural question is whether $J(CD)$ could relate to CP breaking for K and B type mesons, to matter antimatter asymmetry and the large scale parity breaking suggested by CMB data.

2. The simplest guess for the coupling strength of $U(1)$ interaction associated with $J(CD)$ predicts a correct order of magnitude for CP violation for K meson and for the antimatter asymmetry and inspires a more detailed discussion. A general mechanism for the generation of matter asymmetry is proposed, and a model for the formation of disk- and elliptic galaxies is considered. The matter antimatter asymmetry would be apparent in the sense that the CP asymmetry would force matter-antimatter separation: antimatter would reside as dark matter (in TGD sense) inside magnetic flux tubes and matter outside them. Also the angular momenta of dark matter and matter would compensate each other.

Correlation of rotation direction for celestial objects would be a signature for $P$ violation in long scales and $P$ violation could explain large scale spin directions of galaxies. TGD Universe is fractal and the natural expectation is that the correlations are reduced with length scale so that Universe as such would not be rotating. In TGD framework one can also ask whether antimatter is present in a manner not discovered yet and whether the net fermion numbers and angular momenta of matter and antimatter could cancel each other: only fermion number and angular momentum separation would be in question.

This question relates also closely to the origin of galaxies. GRT leads to successful stellar models but in the galactic scales situation is different. The flatness of the spectrum of rotational velocities cannot be understood in terms of baryonic mater, and the halo model of dark matter is in grave difficulties [22][34]. The situation is not much better for MOND (see `http://tinyurl.com/pu36kqg`), which introduces an ad hoc modification of laws of gravitation at low (rather than large!) accelerations. My personal intuition is that galactic dynamics goes beyond the explanatory power of GRT and that the its description should be much simpler than provided by the numerical models based on GRT involving large number of model dependent assumptions. The flat velocity spectrum and long range correlations of galactic spins signaling for cosmic $P$ violation look like a promising starting point for the attempts to go beyond GRT view.

This work was largely inspired by a talk *Is the Universe rotating?* by Chu Ming-chung providing a lot of references and historical view about the evolution of the idea about rotating Universe. The slides can be found at `http://tinyurl.com/mzngctn`. These slides have been of considerable help for myself and are warmly recommended. They also contain numerous illustrations, to which I will link in the sequel.

# 2 Theoretical and empirical background

CMB results suggest large scale rotation and it has been even proposed that the entire Universe is rotating. Gödel Universe would be GRT example of this. This raises several questions. Has the notion of rotating Universe operational meaning? Could the milder milder hypothesis about fractal hierarchy of space-time sheet rotating in the sense that they possess non-vanishing angular momentum. The crucial question concerns the empirical support for the rotation in large length scales and here CMB anomalies are crucial.

In TGD framework one can ask further questions. Could matter and antimatter rotate in opposite directions? What conditions does this pose to the possible mechanism leading to matter antimatter separation? Could antimatter be dark in TGD sense?

## 2.1 Does it make sense to talk about rotating Universe?

Does it make sense to speak of rotating Universe? In other words, can one observe the rotation of the Universe? It is very difficult to look Universe from outside and one might hope that rotation could be detected from inside.

#### 2.1.1 Views of Newton and Mach and TGD vision

This question is encountered also for finite systems. With respect to what do they rotate? Newton assumed absolute time and absolute space and rotation would be with respect to this. For rotating water bucket rotation has a visible consequence as the change of the shape of the water surfaces caused by centrifugal force. Mach was not satisfied with this explanation and proposed that rotation is with respect to the distant stars defining a unique inertial system.

1. In special relativity there is no unique inertial system but one can always distinguish between accelerated and inertial systems so that it is possible to tell whether system rotates in Minkowski space-time or not. The isometries of Minkowski space imply the existence of conserved angular momentum so that can speak about rotation of subsystem if the orbital part of angular momentum is non-vanishing: usually the spin part of much smaller than orbital part. For single vortex one can say that it rotates as a whole. But if this vortex decomposes to smaller vortices spinning in the same direction, it seems that one cannot anymore speak of a rotation of the entire system anymore. The rotation of the entire system requires coherence. A super-fluid rotated with overcritical velocity indeed loses its macroscopic quantum coherence and vortices develop.

   A naive objection against constant rotation velocity $\Omega$ of Universe is that the $v = \omega\rho$ around rotation becomes superluminal at large distances $\rho$ from the rotation axis. This would suggest that the rotation velocity, if non-vanishing, must be scale dependent and approach to zero at last distances like $\Omega \propto 1/\rho$ so that one has flat velocity spectrum. Vanishing vorticity outside the vortex core would require $\Omega \propto 1/\rho^2$.

2. In GRT one does not have unique inertial system either and also Lorentz invariance is lost as symmetries so that in principle one does not have conserved angular momentum. In GRT one has rotating solutions such as Gödel Universe, and one say that in this case one might say that the rotation is with respect to distant stars.

3. In TGD framework there are two senses in which rotation can make sense. Rotation must be absolute that is take place in any system of coordinates. This is guaranteed by general coordinate invariance (GCI). At imbedding space level causal diamond (CD) of imbedding space $H = M^4 \times CP_2$ - kind of mini-Universe as far as conscious perception is considered - defines the universal reference system. CD is analogous to the absolute inertial system of Newton: Lorentz invariant (absolute) time identified as light-cone proper time assignable to either tip of CD. Conserved angular momentum - not existing in GRT in strict sense - defines a measure for amount of rotation. Noether comes in rescue again!

   At space-time level larger space-time sheet at which the system is topologically condensed could serve as such a system. Also the larger space-time sheet could be rotating and cause effects analogous to Coriolis force caused by the rotation of Earth: the shape of hurricane Katrina and typical spiral galaxy are remarkably similar and might be partly due this force: large space-time sheet rotates with respect to the rest system of galaxy like Earth with respect to the rest system of Katrina.

4. What puts bells ringing is the existence of time like closed geodesics. Maybe they make sense after all at GRT limit of TGD, where zero energy ontology (ZEO) allows both arrows of time. In TGD framework the analog of absolute space is provided by the imbedding space $M^4 \times CP_2$ and angular momentum is conserved quantity. Hence one can tell whether space-time sheet rotates and in principle can do this for arbitrarily large space-time sheets. The arrow of time depends on space-time sheet. The violation of $T$ symmetry implied by Kähler form $J(CP)$ allows to distinguish between the two opposite arrows for a given space-time sheet.

#### 2.1.2 Rotation in GRT Universe

In GRT the rotation of the Universe should show itself as the properties of the metric. To get the idea one can write ordinary Minkowski metric in rotating coordinates. One finds that the metric tensor has non-vanishing component $g_{t\phi}$. This serves as a guideline, when on tries to find metrics which would represent rotating systems, which are non-vacua. Kerr metric and Gödel's rotating static Universe [9, 16] are examples of this kind of metrics.

The line element of Gödel metric [9, 16]is of form

$$ds^2 = a^2(d\tau^2 - dx^2 + (exp(2x)/2)dy^2 - dz^2 + 2exp(x)d\tau dy \ \ .$$

The existence of closed light-like geodesics is easily verified by writing the equation $ds^2 = a^2(d\tau^2 + (exp(2x)/2)dy^2 + 2exp(x)d\tau dy = 0$ of light like geodesic in $(\tau, y)$ coordinate plane in the form $\tau = f_x(y)$. Same happens in Kerr metric.

Can one have closed time-like geodesics in TGD Universe: is it possible to make U-turn in time? In $M^4$ coordinates for the space-time sheet conserved energy for the geodesic is proportional to $dm^0/ds$ and must vanish if it turns backwards in time. If there is coupling to the sum of vector potentials of Kähler forms of $M^4$ and $CP_2$ conserved energy contains also the analog of Coulomb energy proportional to $(dm^0/ds)A_0$, which also vanishes at the turning point.

The QFT limit of TGD should give GRT or something near to it. At this limit space-time is not many-sheeted surface anymore but a small deformation of flat Minkowski space. This limit is only an approximation and there are several anomalies suggesting that many-sheeted space-time is more realistic view about space-time.

The instanton density must vanish for the QCD limit of TGD: this solves the strong $CP$ problem of QCD [30]. Perhaps also the analog of instanton density for curvature form could vanish also for the GRT limit of TGD. This constraint profoundly modifies the interpretation of GRT: the sum $T - kG$ would represent non-vanishing energy momentum tensor including contributions assigned to matter and gravitation.

In zero energy ontology (ZEO) both arrows of time are possible in quantum sense and the violation of $T$ is essential for this. Could the predicted violations of $P$, and $T$ in cosmic scales for many-sheeted space-time correspond at GRT limit to the Kerr type metric with closed light-like and time like geodesics? Or does GRT limit simply fail to describe the situation?

#### 2.1.3 Model for the effect of global rotation on the formation of the galaxies

Li-Xin Li has proposed a model in which the rotation of galaxies is caused by the rotation of space-time [11]. The basic observation is that typhoons and galaxies resemble each other. The slides at `http://tinyurl.com/mzngctn` show that hurricane Katrina and disk galaxy $M_{101}$ have very similar visual appearance. In case of Katrina one as pressure gradient (thermodynamical force) towards center and in the case of galaxy gravitational force (virtual force in GRT). For Katrina Earth and therefore also the rest system of Katrina rotates. For galaxy the rotating Universe would replace Earth. The proposal is that the analog of Coriolis force is responsible for the shape of galaxy. The empirical relation $J \propto M^{5/3}$ is explained and the model is claimed to predict two kinds of galaxies: elliptic and spiral. The estimated rotation speed of the Univese is deduced from data and would be $\Omega \sim 10^{-13}$ rad/year.

In TGD framework the presence of long flux tube would give rise to gravitational force forcing the rotation and constant velocity spectrum would give differential rotation explaining the spiral shape of the galaxy.

### 2.2 CMB and rotating Universe

CMB provides model dependent constraints on upper limits on the rotation velocity of the Universe and so called axis of Evil (AE) can be interpreted as indication for the preferred rotation direction in cosmic scales.

### 2.2.1 Constraints on the rotation velocity of Universe from CMB

The CMB contraints on the rotation velocity of Universe come from cosmological models treating rotation as perturbation Robertson-Walker cosmology using CMB data as a constraint.

1. Hawking has deduced a constraint on $\Omega$ for closed universe [15]: $\Omega < 10^{-14} - 7 \times 10^{-17}$ rad/yr.

2. Hawking and Collins have deduced a constraint also for open universe [14]: $\Omega < 2 \times 10^{-17}$ rad/yr .

3. Barrow has deduced a consraint for flat universe [3]: $\Omega < 1.5 \times 10^{-15}$ rad/yr.

4. Ellis and Olive have shown that inflationary cosmology does not allow rotation large scales [8]. Exponential expansion damps any rotation.

In TGD framework the rotation is made possible by the strong gravitational field of long flux tubes along which the galaxies would condense. One has actually fractal hierarchy of flux tubes: local groups of galaxies can take the role of pears attaching to strings and strings could be present also in the scale of stars. Elliptic galaxies have declining velocity spectrum being "free" pearls whereas disk galaxies would be pearls gravitationally bound to the string of the necklace, and circular orbits in $1/\rho$ potential would have constant velocity spectrum. Centrifugal force would would cause the flattening to disk galaxies.

### 2.2.2 Is there a preferred direction in the Universe?

Cosmic microwave background (CMB) predicted by standard cosmology has temperature $T = .2725$ K. The scale of temperature fluctuations $\Delta T/T \simeq 10^{-5}$ corresponds to that for the density fluctuations. The most successful model is inflationary model predicting Gaussian fluctuations, which are isotropic.

However, CMB contains astonishingly large number of anomalies as one learns from the the introduction of the article *Preferred axis in cosmology* by W. Zhao and L. Santos [17] (see `http://tinyurl.com/lr9qbzv`) giving also references to these anomalies. I am not a specialist in this field so that I can only repeat the list of the anomalies given in the introduction of the article: the low quadrupole problem, the lack of both variance and correlation on the largest angular scales, cold spot problem, power asymmetry, hemisphere asymmetry, large-scale quadrant asymmetry, alignment of low multipoles, parity asymmetry, mirror-parity asymmetry, and so on.

Most of these anomalies are directional anomalies and suggest $P$ violation in cosmic scales. One cannot of course exclude that the presence of unknown sources of microwave radiation as an explanation of the anomalies. The anomalies could also reduce to the local physics. If the anomalies have cosmological origin, the prevailing inflationary scenario must be modified.

1. One can express CMB temperature as function of solid angle in terms of spherical harmonics $Y_{lm}(\Omega)$. For given $l$, one can also assign to the temperature fluctuations an axis for, which the dispersion of angular momentum quantum number $m$ is largest. The direction of this axes should be random. For dipole, quadrupole, and octupole spins these axes are however nearly parallel and aligned with the direction of galactic North pole. This defines the Axis of Evil (AE).

   The direction of AE can be expressed in galactic spherical coordinates for which polar angle $\theta$ (latitude $b = \pi/2 - \theta$) with respect to the normal of galactic plane and azimuthal angle $\phi$ (longitude $l$) vanishes along the axis connecting Sun (the origin) to the center of galaxy. From WMAP data AE has coordinates $(b, l) \simeq (50^\circ, -90^\circ)$ [2] (for illustration see `http://tinyurl.com/mzngctn`).

   In Earth centered coordinates with z-axis is orthogonal to the equitorial plane defining the celestial equator. The counterparts of latitude and longitude are declination and right ascension. The declinations associated with the dipole, quadrupole, and octupole (except for one of two WMAP octopoles) are in the range $[-7°, 16°]$. RAs are near to the axes with $RA = 180°$. AE corresponds roughly to the direction of Virgo constellation (for illustration see http://tinyurl.com/kr3lma8). Note that AE is almost in the equatorial plane of Earth, which raises the question about local explanation of AE unless the equatorial plane of Earth is parallel to a plane of some structure in larger length scale.

2. The alignment of lower multiples from $l = 1$ to $l = 5$ provide an example of directional anomaly. $l = 1$ anomaly is thought to be purely kinematical and due to the motion of local galaxy cluster with respect to cosmic background. What is strange that $l = 1$ happens to be aligned with the other multipoles: as if the local cluster would be moving along the preferred direction appearing in much large scale - the axis of evil (AE).

   The parity asymmetry between odd and even partial waves is second anomaly: even partial waves have anomalously low amplitudes and odd partial waves anomalously large values indicating parity violation in cosmic scales.

3. Preferred directions are reported in a number of other cosmological observations: the velocity flows, quasar alignment, anisotropy of the cosmic acceleration, the handedness of spiral galaxies, and angular distribution of the fine-structure constant. Even though there are many debates, it has been also reported that all these preferred directions seem to coincide with the CMB kinematic dipole. Also here references can be found from [17] (see http://tinyurl.com/lr9qbzv).

   For ordinary spherically symmetric statistics the directional anomalies cancel in the sense that one obtains same result for any choice of spherical coordinates. Therefore the authors of [17] study the possible presence of preferred directions by using directional statistics breaking rotational invariance or axial symmetry with respect to fixed axis (one drops the $m = 0$ component from spherical harmonics and finds by statistical methods an axis for which $P$ violation is maximal).

   The axis found in this manner has strong correlations with AE and with the CMB kinematic dipole. The kinematic dipole is caused by the motion of local group of galaxies in the direction of the galactic coordinates $(\theta = 42°, \phi = 264°)$. If the directions of various directional anomalies correspond to same direction, there is temptation to conclude that the anomaly is local.

4. The data can be also characterized by so called multipole vectors in 3-space [5] (see http://tinyurl.com/lxv4zmf). For $l = 1$ harmonics they are are defined by the 3 coefficients of $l = 1$ partial waves $c^{1m}$ defining a direction vector in 3-space. Higher partial waves are representable as symmetrized tensor products formed from $l = 1$ partial waves and orthogonalized with respect to the lower partial waves so that one can assign to $l \geq 1$ contributions $l$ multipole vectors. For low values of $l$ this vectors tend to aligm.

What about TGD view?

1. Directional anomalies are predicted by the twistor lift of TGD and would be due to the analog of covariantly constant Kähler form assignable to causal diamond (CD) in given scale defining preferred direction as quantization axis of angular momentum and time direction fixing rest system violating both $CP$, $P$, and $T$ and perhaps involved also with matter antimatter asymmetry and macroscopic arrow of time. CDs would relate to quantum measurements in even cosmic scales.

2. The lack of both variance and correlation on the largest angular scales and large scale quadrant asymmetry (see http://tinyurl.com/mzaklg4) could be seen as a support for many-sheeted space-time: space-time sheets having interpretation as coherence regions have a finite size as do also CDs. Fractal hierarchy of parity violations such that the violation gets weaker in longer scales, is highly suggestive. Instead of anomaly in cosmic scale one could have a hierarchy of local parity violations.

## 2.3 Models for the $P$ violation in long length scales

On the following two models for long length scale $P$ possibly explaining the anomalies of CMB are discussed.

### 2.3.1 Is the cosmological AE due to a large-scale magnetic field?

M. J. Longo has studied the presence of parity violation in scales below .7 Gly [12] (see the article *Does the Universe have a handedness?* at `http://tinyurl.com/l2aueq8`). The conclusion is that there is a strong signal for the preference for galaxies to be either left- or right-handed: one has $(N_R - N_L)/(N_L + N_R) \simeq 8$ per cent at northern celestial hemisphere (celestial equator is parallel to the Earth's equator). The probability for the occurrence of this asymmetry b change is estimated to be $\sim 3.0 \times 10^{-4}$. The asymmetry axis has $(\delta, RA) \sim (25°, 202°)$ with uncertainty of $\sim 15°$. The axis is aligned with AE having $(\delta, RA) \sim (4°, 173°)$. Milky Way is along with this axis within $8.4°$ or this spiral axis.

M. J. Longo considers in the article *Is the Cosmic "Axis of Evil" due to a Large-Scale Magnetic Field?* [13] (see `http://tinyurl.com/m2f3cm3`) the possibility that the preferred direction could be due to the presence of magnetic field in the direction of AE and proposes inverse Compton scattering from the electron currents rotating around the axis of this magnetic field as a concrete mechanism for the generation of AE. I attach here the abstracti of the article.

*I propose a mechanism that would explain the near alignment of the low order multipoles of the cosmic microwave background (CMB). This mechanism supposes a large-scale cosmic magnetic field that tends to align the cyclotron orbit axes of electrons in hot plasmas along the same direction. Inverse Compton scattering of the CMB photons then imprints this pattern on the CMB, thus causing the low-l multipoles to be generally aligned. The spins of the majority of spiral galaxies and that of our own Galaxy appear to be aligned along the cosmic magnetic field.*

The article mentions that Campanelli et al. [4] propose that the power suppression in the low-$l$ multipoles can be explained if the universe is "ellipsoidal" with an axis generally along the direction of the quadrupole. They suggest that the eccentricity is produced by a cosmic magnetic field $B_0 = (4-5) \times 10^{-9}$ Gauss.

In TGD framework magnetic flux tubes are the basic structures and suggest the following vision.

1. Disk galaxies are organized along flux tubes like pearls in necklace and the model correctly predicts the flat rotation curve of disk galaxies forming bound states with flux tubes and the declining rotation curve for elliptic galaxies, which would not form bound states with flux tubes. The magnetic fields associated with $M^4$ ($J(CD)$) and ordinary magnetic fields associated with $CP_2$ could be present.

   Magnetic field strength is inversely proportional to the thickness of the $M^4$ projection, which allows to estimate the thickness from flux quantization. For unit flux quantum the the thickness of the flux tube for $B_0 = 4 \times 10^{-9}$ Gauss would be of order 7 cm - a biological scale. One expects large number of these flux tubes. In TGD framework one cannot talk about single global direction but fractal hierarchy of preferred directions defining quantization axis in terms of the flux tube directions of magnetic fields.

2. The origin of magnetic fields in cosmic scale is a mystery in standard model. In TGD framework the non-trivial homology of $CP_2$ allows magnetic flux tubes having closed 2-surface rather than disk as cross section and possessing integer valued magnetic flux. This kind of monopole fluxes does not need any current to generate them (induction coils in electronics) . Therefore these fluxes are topologically stable and would have been present already in primordial cosmology dominated by a gas of long cosmic strings.

3. The counterpart for inflationary period is a period when ordinary space-time was generated as long cosmic strings topologically condensed at emerging space-time sheets and their $M^4$ projection

began to thicken. Flux tubes suffered topological condensation at thicker flux tubes. The decay of closed cosmic strings to ordinary particles analogous to the decay of inflaton field occurred in the reconnections of flux tubes and led to the formation of galaxies and large structures.

4. If AE is a local phenomenon in galactic scale, the first guess is that the preferred direction defining the axis of the magnetic field is roughly orthogonal to the galactic equatorial plane ($\theta \sim 90°$). The reason would be that the flux tube containing Milky Way as a pearl in necklace defines radial gravitational field in radial direction orthogonal to it and thus defines the galactic plane. The direction is however $\theta \sim 42°$. The first explanation is that the direction of AE is associated with a local cluster of galaxies and need not be the same as the direction of the flux tube assignable to Milky Way.

   Interestingly, there is evidence about so called vast polar structure (VPS) consisting of dwarf galaxies rotating in a plane orthogonal to galactic plane and that Milky Way might have experienced kind of cosmic traffic accident with with a galaxy for which the long flux tube would be orthogonal to that for Milky Way [1] (see `http://tinyurl.com/k553545`). If two nearly orthogonal magnetic flux tubes are involved, the magnetic field experienced by charged particles in the many-sheeted space-time is sum of these magnetic fields and would be in the direction of AE.

**Remark:** It is of some interest to notice that in TGD inspired theory of consciousness various important biorhythms correspond to cyclotron time scales. The alpha band at 10 Hz corresponds to the cyclotron frequency of $Fe^{++}$ ion in "endogenous" magnetic field $B_{end} = 2/5 \times B_E = B.2 \times 10^{-4}$ Gauss. By scaling the cyclotron time .1 seconds of $Fe^{++}$ ion in $B_0 = 4 \times 10^9 = 2 \times 10^{-8} B_{end}$ would be about 2 months, a biological time scale. One can wonder whether this is mere accident.

### 2.3.2 Super-fluid Universe of Kerson Huang

The model of superfluid model of cosmology by Kerson Juang is an attempt to build a variant of inflation theory allowing to have rotation in cosmic scales, and perhaps also to explain the CBM anomalies. The article *Fantasia of a Superfluid Universe In memory of Kerson Huang* by Low and Xiong [7] (see `http://tinyurl.com/lbzt44o`) gives an idea about what is involved. It is instructive to compare the approach of Huang to that of Witten analogous to TGD approach.

The superfluid Universe of Huang makes the following basic hypothesis:

1. The asymptotically free Halpern-Huang scalar field(s) to drive inflation. This scalar field defines an order parameter for super-fluidity. The scalar field as rather complex non-polynomial potential and this could be criticized. Also the assumption about inflation can be subjected to criticism.

2. Quantum turbulence creates matter. Quantum turbulence would be associated with the string like defect lines of the order parameter analogous to vortex cores in ordinary superfluidity. These defect lines can get knotted and linked and can form a complex tangle. They can also reconnected and in this process the energy of the ground states of the order parameter could decay to ordinary matter.

3. Dark energy is the energy density of the cosmic superfluid and dark matter is the deviation of the superfluid density from its equilibrium value.

4. Quantum vorticity would explain phenomena such as the non-thermal filaments at the galactic center, the large voids in the galactic distribution, and the gravitational collapse of stars to fast-rotating blackholes.

Comparison with TGD reveals obvious differences but also common aspects.

1. Inflation is replaced in TGD by the transition from a phase dominated by cosmic strings to a radiation dominated cosmology and the decay of inflaton field is replaced with the decay of magnetic

flux tubes to radiation. The identification of dark energy and matter is also different in TGD framework.

2. Also in TGD quantum turbulence would generate matter. In TGD however the flux tubes carrying super-currents/super-fluid flows would be the basic topological entities rather than the defects emerging in the QFT type description of these entities using complex scalar fields.

3. The vortices of supraflow would be generated by heat, collisions of galaxies, and fast rotating systems such as galaxies and blackholes and would not directly correspond to entities observed in cosmology. In TGD framework the flux tubes carrying dark energy and matter would replace the vortices and make themselves visible via the flatness of the velocity spectrum of galaxies.

4. In TGD the superconducting flux tubes would take the role of vortex lines in the modeling above mentioned phenomena such as non-thermal filaments at the galactic center, the large voids, and the gravitational collapse.

In the article *Relativistic superfluidity and vorticity from the nonlinear Klein-Gordon equation* [10] (see `http://tinyurl.com/mrhgv2s`) by Huang et al consider a model for rotating super-fluid using complex scalar field obeying non-linear Klein Gordon equation and deduce from in rotating coordinates the quantum counterparts of centrifugal and Coriolis force terms in Minkowski space generalized to GRT. Also non-relativistic limit is considered.

The scalar field of Huang is taken as a fundamental field.

1. One can argue that this is only a macroscopic description for the particles forming the Bose-Einstein condensate as it is the ordinary super-conductivity and super-fluidity. The highly non-trivial implication would be that mean that these phases indeed exist in cosmological scales. The deeper challenge would be the identification of the "microscopic" entities described by the order parameter.

2. Witten's cosmic strings is an example of this kind of "microscopic" entities. For Witten's superconducting cosmic strings a spontaneous breaking of electromagnetic symmetry takes place inside cosmic strings as in ordinary super-conductivity (Meissner effect). Currents inside strings create strong magnetic fields around the string. Also radial electric fields are generated. Superconducting cosmic strings would not be vortices but basic current carriers.

In TGD the magnetic flux tubes emerge from cosmic strings as they thicken during cosmic evolution. They would be analogous to Witten's cosmic strings, and could serve as wires of both em and $U(1)$ currents. If one wants to use order parameter, one should assign it with single flux tube or maybe pair of them carrying Cooper pairs which define the basic superconducting structures in the TGD inspired model of high $T_c$ superconductivity. It is these object, which would allow to understand CMB anomalies. It could happen that the net $U(1)$ charge density and current vanish inside flux tubes so that $U(1)$ fields outside flux tubes are not generated as in the case of Witten's superconducting strings.

The TGD inspired model of high $T_c$ super-conductor or super-fluidity analogous to the model of Witten for cosmic string as super-conductor would appear as a fundamental description. It is essential that one has large $h_{eff}$ phase. One canimagine three options.

1. One could have BE condensate of fundamental bosons at single flux tube for both super-conductivity and super-fluidity.

2. One could also have a Bose condensate of Cooper pairs. In the TGD based model of high $T_c$ super-conductivity [25, 26], the flux tubes would appear as pairs with magnetic fluxes in opposite or parallel directions. The members of Cooper pairs would be charged particles associated with different parallel flux tubes would have total spin 0 or or 1 for the two options.

3. $h_{eff}/h = n$ implies $n$-sheeted covering structure for the space-time surface. Could one have $m \leq n$ -fermion states with fermions at different sheets? These states would apparently break fermionic statistics since they are analogous to fermionic Bose-Einstein condensates. Or does $1/n$ fractionization of fermion number take place?

The QFT-GRT limit of TGD replaces the many-sheeted space-time with a slightly curved metric deformation of Minkowski space and closed flux tubes carrying super-currents/supraflows are idealized with point like particles described by a complex order parameter. Could the analog of the super-fluid Universe of Huang emerge at this limit? It is obvious that the line singularities for this order parameter have nothing to do with the the flux tubes so that the information about CMB anomalies would be lost in this description. To sum up, it seems that the physics behind Huang's model and TGD are very different.

Two remarks are in order.

1. An open question is whether the quantum for angular momentum should be taken $\hbar_{eff}$ in which case the particles would be analogous Bose Einstein condensates with charged particles at different sheets of the covering having the same $M^4$ projection. TGD Universe is quantum critical system and there is temptation to think that this phenomenon occurs in all scales.

2. If fractality is taken at face value, one is led to ask whether also stars form necklace like structures. The string tension of flux tube in question should be so low that the deviation of the gravitational potential from $1/r$ form is not significant in the scale of planetary system. At large enough distances one should however obtain a flat velocity spectrum for objects rotating around Sun in circular orbits whereas for $1/r^2$ forces the velocities behave like $1/\sqrt{r}$. I it possible that this would have remained undetected?

# 3 Kähler form of $M^4$ as source of large scale breaking of $CP$, $P$ and $T$

The analog of Kähler form for $M^4$ - or rather - for CD and depending on it - is a central element of the twistor lift of TGD.

## 3.1 The analog of Kähler structure of $M^4$ is forced by twistor lift of TGD

Twistor lift of TGD forces to assume the analog of self-dual covariantly constant Kähler form $J(M^4)$ for Minkowski space $M^4$ contributing to the Kähler form (or rather for causal diamond (CD) of $M^4$). $J(CD)$ corresponds to the presence of parallel constant $U(1)$ electric and magnetic fields coupling to fermion number. This is the just prerequisite for charge separation in CME [30]!

1. Does the $M^4$ Kähler form contribute to the $U(1)$ of em field or does it represent a classical field of its own? $J(CD)$ couples to fermion number. In particular, it has also a coupling to right-handed neutrinos! Since neutrinos are em neutral this allows only the interpretation as an additional $U(1)$ field coupling to fermion number. Right-handed neutrinos should be extremely weakly interacting, which demands that the preferred extremals are such that the electric component of $J(CD)$ is small. Alternatively, $\alpha_1$ is small.

2. In TGD the induced $J(CD)$ field created by the density of nuclear baryonic number replaces the electromagnetic field created by a constant charge density in HN-HN collisions. For the canonical imbedding of $M^4$ the induced $J(CD)$ would be self-dual and charge separation would be forced by $J(CD)$ in the direction defined by the $M^4 = M^2 \times E^2$ decomposition defined by $J(CD)$. There is strong temptation to think that matter-antimatter asymmetry is basically due to CME along $U(1)$ magnetic flux tubes connecting the regions containing matter and antimatter.

3. $J(CD)$ couples to the difference of fermion numbers defined as $F = B - L$ with electron and proton agreed to have the same fermion number. Since leptons and and baryons have opposite fermion numbers, $U(1)$ flux tubes as counterparts of field lines can connect baryons and leptons. Note that atoms have non-vanishing $U(1)$ charge $F$ given by neutron number.

4. What is important that space-time surfaces themselves satisfy the analogs of field equations for point like particles in $U(1)$ field. They are obtained by replacing point like particles 3-D objects. This is one of the key predictions of twistor lift of TGD predicting that 4-D action contains a volume term besides Kähler action. The volume term alone would give the analog of geodesic motion and Kähler action adds coupling to $U(1)$ force. Asymptotic state are minimal surfaces analogous to geodesics having vanishing $U(1)$ force. $U(1)$ force appears only in transient situations like particle scattering events. The first interpretation of volume term would be in terms of cosmological constant. It however seems that the more plausible interpretation of the entire action is in terms of cosmological constant.

## 3.2 Quantitative picture about CP breaking in TGD

One must specify the value of $\alpha_1$ and the scaling factor transforming $J(CD)$ having dimension length squared as tensor square root of metric to dimensionless $U(1)$ gauge field $F = J(CD)/S$. This leads to a series of questions.

How to fix the scaling parameter $S$?

1. The scaling parameter relating $J(CD)$ and $F$ is fixed by flux quantization implying that the flux of $J(CD)$ is the area of sphere $S^2$ for the twistor space $M^4 \times S^2$. The gauge field is obtained as $F = J/S$, where $S = 4\pi R^2(S^2)$ is the area of $S^2$.

2. Note that in Minkowski coordinates the length dimension is by convention shifted from the metric to linear Minkowski coordinates so that the magnetic field $B_1$ has dimension of inverse length squared and corresponds to $J(CD)/SL^2$, where $L$ is naturally be taken to the size scale of CD defining the unit length in Minkowski coordinates. The $U(1)$ magnetic flux would the signed area using $L^2$ as a unit.

How $R(S^2)$ relates to Planck length $l_P$? $l_P$ is either the radius $l_P = R$ of the twistor sphere $S^2$ of the twistor space $T = M^4 \times S^2$ or the circumference $l_P = 2\pi R(S^2)$ of the geodesic of $S^2$. Circumference is a more natural identification since it can be measured in Riemann geometry whereas the operational definition of the radius requires imbedding to Euclidian 3-space.

How can one fix the value of $U(1)$ coupling strength $\alpha_1$? As a guideline one can use CP breaking in K and B meson systems and the parameter characterizing matter-antimatter symmetry.

1. The recent experimental estimate for so called Jarlskog parameter characterizing the CP breaking in kaon system is $J \simeq 3.0 \times 10^{-5}$. For B mesons CP breading is about 50 times larger than for kaons and it is clear that Jarlskog invariant does not distinguish between different meson so that it is better to talk about orders of magnitude only.

2. Matter-antimatter asymmetry is characterized by the number $r = n_B/n_\gamma \sim 10^{-10}$ telling the ratio of the baryon density after annihilation to the original density. There is about one baryon 10 billion photons of CMB left in the recent Universe.

Consider now the identification of $\alpha_1$.

1. Since the action is obtained by dimensional reduction from the 6-D Kähler action, one could argue $\alpha_1 = \alpha_K$. This proposal leads to unphysical predictions in atomic physics since neutron-electron $U(1)$ interaction scales up binding energies dramatically.

$U(1)$ part of action can be however regarded a small perturbation characterized by the parameter $\epsilon = R^2(S^2)/R^2(CP_2)$, the ratio of the areas of twistor spheres of $T(M^4)$ and $T(CP_2)$. One can however argue that since the relative magnitude of $U(1)$ term and ordinary Kähler action is given by $\epsilon$, one has $\alpha_1 = \epsilon \times \alpha_K$ so that the coupling constant evolution for $\alpha_1$ and $\alpha_K$ would be identical.

2. $\epsilon$ indeed serves in the role of coupling constant strength at classical level. $\alpha_K$ disappears from classical field equations at the space-time level and appears only in the conditions for the super-symplectic algebra but $\epsilon$ appears in field equations since the Kähler forms of $J$ resp. $CP_2$ Kähler form is proportional to $R^2(S^2)$ resp. $R^2(CP_2)$ times the corresponding $U(1)$ gauge field. $R(S^2)$ appears in the definition of 2-bein for $R^2(S^2)$ and therefore in the modified gamma matrices and modified Dirac equation. Therefore $\sqrt{\epsilon} = R(S^2)/R(CP_2)$ appears in modified Dirac equation as required by CP breaking manifesting itself in CKM matrix.

   NTU for the field equations in the regions, where the volume term and Kähler action couple to each other demands that $\epsilon$ and $\sqrt{\epsilon}$ are rational numbers, hopefully as simple as possible. Otherwise there is no hope about extremals with parameters of the polynomials appearing in the solution in an arbitrary extension of rationals and NTU is lost. Transcendental values of $\epsilon$ are definitely excluded. The most stringent condition $\epsilon = 1$ is also unphysical. $\epsilon = 2^{2r}$ is favoured number theoretically.

Concerning the estimate for $\epsilon$ it is best to use the constraints coming from p-adic mass calculations.

1. p-Adic mass calculations [24] predict electron mass as

$$m_e = \frac{\hbar}{R(CP_2)\sqrt{5+Y}} \quad .$$

   Expressing $m_e$ in terms of Planck mass $m_P$ and assuming $Y = 0$ ($Y \in (0,1)$) gives an estimate for $l_P/R(CP_2)$ as

$$\frac{l_P}{R(CP_2)} \simeq 2.0 \times 10^{-4} \quad .$$

2. From $l_P = 2\pi R(S^2)$ one obtains estimate for $\epsilon$, $\alpha_1$, $g_1 = \sqrt{4\pi\alpha_1}$ assuming $\alpha_K \simeq \alpha \simeq 1/137$ in electron length scale.

$$\begin{aligned} \epsilon &= 2^{-30} \simeq 1.0 \times 10^{-9} \quad , \\ \alpha_1 &= \epsilon\alpha_K \simeq 6.8 \times 10^{-12} \quad , \\ g_1 &= \sqrt{4\pi\alpha_1} \simeq 9.24 \times 10^{-6} \quad . \end{aligned}$$

There are two options corresponding to $l_P = R(S^2)$ and $l_P = 2\pi R(S^2)$. Only the length of the geodesic of $S^2$ has meaning in the Riemann geometry of $S^2$ whereas the radius of $S^2$ has operational meaning only if $S^2$ is imbedded to $E^3$. Hence $l_P = 2\pi R(S^2)$ is more plausible option.

For $\epsilon = 2^{-30}$ the value of $l_P^2/R^2(CP_2)$ is $l_P^2/R^2(CP_2) = (2\pi)^2 \times R^2(S^2)/R^2(CP_2) \simeq 3.7 \times 10^{-8}$. $l_P/R(S^2)$ would be a transcendental number but since it would not be a fundamental constant but appear only at the QFT-GRT limit of TGD, this would not be a problem.

One can make order of magnitude estimates for the Jarlskog parameter $J$ and the fraction $r = n(B)/n(\gamma)$. Here it is not however clear whether one should use $\epsilon$ or $\alpha_1$ as the basis of the estimate

1. The estimate based on $\epsilon$ gives

$$J \sim \sqrt{\epsilon} \simeq 3.2 \times 10^{-5} \quad , \quad r \sim \epsilon \simeq 1.0 \times 10^{-9} \quad .$$

   The estimate for $J$ happens to be very near to the recent experimental value $J \simeq 3.0 \times 10^{-5}$. The estimate for $r$ is by order of magnitude smaller than the empirical value.

2. The estimate based on $\alpha_1$ gives

$$J \sim g_1 \simeq 0.92 \times 10^{-5} \quad , \quad r \sim \alpha_1 \simeq .68 \times 10^{-11} \quad .$$

The estimate for $J$ is excellent but the estimate for $r$ by more than order of magnitude smaller than the empirical value. One explanation is that $\alpha_K$ has discrete coupling constant evolution and increases in short scales and could have been considerably larger in the scale characterizing the situation in which matter-antimatter asymmetry was generated.

There is an intriguing numerical co-incidence involved. $h_{eff} = \hbar_{gr} = GMm/v_0$ in solar system corresponds to $v_0 \simeq 2^{-11}$ and appears as coupling constant parameter in the perturbative theory obtained in this manner [22]. What is intriguing that one has $\alpha_1 = v_0^2/4\pi^2$ in this case. Where does the troublesome factor $(1/2\pi)^2$ come from? Could the p-adic coupling constant evolutions for $v_0$ and $\alpha_1$ correspond to each other and could they actually be one and the same thing? Can one treat gravitational force perturbatively either in terms of gravitational field or $J(CD)$? Is there somekind of duality involved?

Atomic nuclei have baryon number equal the sum $B = Z + N$ of proton and neutron numbers and neutral atoms have $B = N$. Only hydrogen atom would be also $U(1)$ neutral. The dramatic prediction of $U(1)$ force is that neutrinos might not be so weakly interacting particles as has been thought. If the quanta of $U(1)$ force are not massive, a new long range force is in question. $U(1)$ quanta could become massive via $U(1)$ super-conductivity causing Meissner effect. As found, $U(1)$ part of action can be however regarded a small perturbation characterized by the parameter $\epsilon = R^2(S^2)/R^2(CP_2)$. One can however argue that since the relative magnitude of $U(1)$ term and ordinary Kähler action is given by $\epsilon$, one has $\alpha_1 = \epsilon \times \alpha_K$.

Quantal $U(1)$ force must be also consistent with atomic physics. The value of the parameter $\alpha_1$ consistent with the size of $CP$ breaking of K mesons and with matter antimatter asymmetry is $\alpha_1 = \epsilon\alpha_K = 2^{-30}\alpha_K$.

1. Electrons and baryons would have attractive interaction, which effectively transforms the em charge $Z$ of atom $Z_{eff} = rZ$, $r = 1 + (N/Z)\epsilon_1$, $\epsilon_1 = \alpha_1/\alpha = \epsilon \times \alpha_K/\alpha \simeq \epsilon$ for $\alpha_K \simeq \alpha$ predicted to hold true in electron length scale. The parameter

$$s = (1 + (N/Z)\epsilon)^2 - 1 = 2(N/Z)\epsilon + (N/Z)^2\epsilon^2$$

would characterize the isotope dependent relative shift of the binding energy scale.

The comparison of the binding energies of hydrogen isotopes could provide a stringent bounds of the value of $\alpha_1$. For $l_P = 2\pi R(S^2)$ option one would have $\alpha_1 = 2^{-30}\alpha_K \simeq .68 \times 10^{-11}$ and $s \simeq 1.4 \times 10^{-10}$. $s$ is by order of magnitude smaller than $\alpha^4 \simeq 2.9 \times 10^{-9}$ corrections from QED (see `http://tinyurl.com/kk9u4rh`). The predicted differences between the binding energy scales of isotopes of hydrogen might allow to test the proposal.

2. $B = N$ would be neutralized by the neutrinos of the cosmic background. Could this occur even at the level of single atom or does one have a plasma like state? The ground state binding energy of neutrino atoms would be $\alpha_1^2 m_\nu/2 \sim 10^{-24}$ eV for $m_\nu = .1$ eV! This is many many orders of magnitude below the thermal energy of cosmic neutrino background estimated to be about $1.95 \times 10^{-4}$ eV (see `http://tinyurl.com/ldu95o9`). The Bohr radius would be $\hbar/(\alpha_1 m_\nu) \sim 10^6$ meters and same order of magnitude as Earth radius. Matter should be $U(1)$ plasma. $U(1)$ superconductor would be second option.

## 3.3 Critical comments

One can represent an objection against the assumption that only covariantly constant $J(CD)$ are allowed: one can imagine also spherically and cylindrically symmetric and Lorentz invariant $J(CD)$s. Consider the $U(1)$ Coulomb field of point charge.

1. Should one assign the $U(1)$ electric flux with radial flux tubes? One would assign to each flux tube $M^4$ Kähler form $J(CD)$ for which the directions of electric and magnetic fields are in the direction of the flux tube. Every flux tube would be accompanied by its own CD and $J(CD)$! This means a lot of CDs, which also overlap! The overlapping CDs would naturally correspond to different space-time sheets perhaps with different size scales.

   What can one say about the relationship of zero energy states a associated with parallel space-time sheets connected by wormhole contacts. These space-time sheets are within respective CDs with either boundary a passive boundary. Suppose that a state function reduction for opposite boundary of CD occurs at the larger space-time sheet. What happens at spacetime sheets at smaller space-tme sheets condensed at it. The change of zero energy states should be induced at the connecting wormhole contacts. The change should leave the parts of zero energy states at passive boundary un-affected as also classical causality would suggest.

   Is this too complex? Why so much CDs are allowed? The proposed explanation is that CD represents the perceptive field of a conscious entity and the preferred directions of CD fix the rest system and spin quantization axis associated with it [33]. CDs would represent the analog for the covering by open sets defining topological space or manifold. In TGD the notion of adelic/monadic manifold requires an analogous covering with CDs associated with the discrete set of points of space-time surface with the property that the coordinates belong to an extension of rationals [31]. Conscious entities assignable to CDs would form an analog for the covering of manifold by charts of an atlas providing conscious map of the space-time surface. This covering would also give cognitive maps in the p-adic sectors of the adelic space-time.

2. The simple minimal surface solutions [28] serving as models for stellar objects are lost if only covariantly constant $J(CD)$:s are allowed and can appear as approximations only.

   Should one accept also non-covariantly constant self-dual $J(CD)$:s with radial electric and magnetic fields necessarily having electric charge and magnetic monopole at the time-like line connecting the tips of CD? Self-dual $J(CD)$ with $J_{\theta\phi} \propto sin(\theta)$ and $J^{0r} = \epsilon^{0r\theta\phi} J_{\theta\phi}$ (note that $\epsilon^{0r\theta\phi}$ is permutation symbol divided by $1/\sqrt{g_4}$ having em charge and magnetic monopole charge at the line connecting the tips of CD would satisfy the conditions. Genuine monopole singularity is however not an attractive idea. Lorentz invariant solution in Robertson-Walker coordinates $(a, r, \theta, \phi)$ is completely analogous. Cylindrically symmetric variant would have fermion charge density along 2-D surface within CD $M^2$ and is unphysical.

Clearly, the first option suggesting deep connection between the notions of topological space and manifold, number theory, and consciousness theory is the more plausible one.

## 3.4 Could the violations of $CP$, $P$, and $T$ correlate?

If $CP$, $P$, and $T$ were symmetries they would transform self-dual $J(CD)$ to antiself-dual form [32]. If these variants of $J(CD)$ are not allowed in the moduli space of $J(CD)$s, one has simultaneous violation of all these symmetries in all scales. One would expect strong correlations between violations of $CP$, $P$, and $T$. The violation of $CP$ in hadronic systems is discussed in [32] and [30], where also $P$ violation is considered and assigned with TGD analogs of chiral magnetic effect (CME) and chiral selection effect (CSE) proposed in QCD framework.

### 3.4.1 Matter antimatter asymmetry and $J(M^4)$

There are several questions to be answered. Could matter antimatter asymmetry be due to the $CP$ breaking in the scale of given space-time sheets due to $J(M^4)$ projection? Could it be due to the separation of matter and antimatter along flux tubes of $J(M^4)$ and be analogous to the so called chiral magnetic effect (CME) and chiral separation effect (CSE) inspired originally by QCD [30]? A necessary condition would be the presence of nearly parallel electric and magnetic fields, and $J(CD)$ would provide these fields and fermions and antifermions would be driven to opposite directions along the flux tubes.

A more plausible option is following. The reconnection for flux tubes could lead to the decay of dark energy of flux tubes to elementary particles and by $CP$ breaking anti-fermion number would generated inside flux tubes containing dark matter and fermion number would be generated in their exterior containing ordinary matter. After annihilation this would lead to matter antimatter asymmetry and apparent disappearance of antimatter.

### 3.4.2 Parity violation and large scale rotation

Could the violation of $P$ in galactic scales and even in cosmic scales - as suggested by CMB anomalies - relate to the breaking of $P$ caused by $J(CD)$ definition quantization axis for macroscopic quantum coherence regions defined by CDs? Could $h_{gr} = h_{eff} = n \times h$ phases with quantum coherence even in cosmic scales relate to the generation of correlations for spin directions of galaxies? Could the many-sheeted space-time implying a hierarchy of CDs assignable to flux tubes with increasingly large cross section allow to understand the generation of net angular momentum of matter at given level of hierarchy?

Ordinary matter would naturally rotate around the flux tubes in its gravitational field and have a flat velocity spectrum asymptotically. If hydrodynamic approximation makes sense, the rotation direction would be same for all subsystems and net angular momentum would be generated but it is not at all clear why the ordinary matter would have net angular momentum. However, the macroscopic quantum phases inside dark matter flux tubes rotating at cyclotron orbits would naturally have non-vanishing angular momentum and conservation of angular momentum would force ordinary matter to have opposite angular momentum. This mechanism is possible in all length scales by fractality.

$P$ violation would manifest itself in the tendency of the spin direction of the spinning dark antimatter inside flux tubes to be preferentially right- or left-handed. Angular momentum conservation would induce similar preference for the spin directions of galaxies.

Parity breaking in living matter manifesting itself as chiral selection could have similar origin. ATPase is a protein central for metabolism and is analogous to the rotating generator of power plant transforming ADP to ATP and feeding to ATP energy serving as a metabolic energy currency. $P$ violation strongly suggests a preferred direction of rotation. For "wrong" direction of rotation the generator would transform to a motor soaking up energy from environment. The anomalous behavior found by Russian researchers Roschin and Godin [18] in rotating magnetic systems involves also parity violation [20]. The system is reported to depicts apparent antigravitational effect and spontaneously accelerate above critical rotation frequency about 10 Hz (fundamental bio-rhythm!). This happens only for the second rotation direction. Also cooling of air around the system is reported in conflict with thermodynamical expectations and suggests time reversal at some space-time sheets.

### 3.4.3 Cosmic $T$ violation and dominant arrow of time

TGD inspired theory of consciousness relies on zero energy ontology (ZEO) and predicts that conscious entities - selves - can have both arrows of time. Zero energy states are pairs of positive and negative energy states associated with opposite boundaries of causal diamond (CD). The passive boundary remains fixed during the state function sequences defining self as also the members of state pairs at it. The opposite (active) boundary shifts farther away and states at it suffer a sequence of unitary evolutions in the sequence fo state function reductions defining self as generalized Zeno effect. In the first reduction to the opposite boundary self dies and reincarnates as self with opposite arrow of clock time. Different arrows of time correspond to the growth of CD to opposite directions.

The usual view is that there is universal arrow of time. In TGD framework the flips for the arrow of time occurs in all possible scales. In living matter there is evidence for both arrows of time and already Fantappie realized this and proposed that syntropy as time-reversal of entropy is needed in order to understand living matter [19].

There are several questions to be answered.

1. Why it is so difficult to systems have the non-standard arrow of time? What about living system. Could we actually experience it - say during sleep and unconscious states? Could $T$ violation relate to the belief that the arrow of time is universal. For instance, could $T$ violation imply that the life-times of selves with standard arrow of time are much longer than those with non-standard arrow of time sos that the standard arrow of time would dominate?

2. Suppose that one can speak about dominant arrow of time. Could the dominant arrow of time for dark antimatter be opposite to that for matter?

In GRT metrics for rotating systems such as Kerr metric and Göedel metric for rotating Universe have closed time like geodesics so that the arrow of time is not global. GRT is expected to be QFT limit of TGD in long scales. What could be the space-time correlates for the arrow of time be in TGD? Could rotating systems have arrow of time opposite to that for their exterior? Could macroscopic $T$ violation have classical space-time correlates?

1. At the fundamental level one cannot have closed time like geodesics in TGD. This would require that the derivative of $M^4$ time with respect to the internal time of space-time surface changes and this implies that system has vanishing energy.

2. $T$ breaking however means that the preferred extremals for given CD are not time reversals with respect to the center point of CD and in this sense the arrow of time has space-time correlates.

3. Could parallel space-time sheeets connected by wormhole contacts with Euclidian signature of metric and thus the corresponding CDs have opposite arrows of time?

# 4 Matter antimatter asymmetry and large scale rotation as aspects of $U(1)$ charge separation due to $J(CD)$

The presence of $J(CD)$ implies simultaneous violations of $CP$, $P$, and $T$ and suggests that matter antimatter asymmetry and large scale rotation are aspects of the same phenomenon leading to a separation of opposite $U(1)$ charges.

## 4.1 Is dark antimatter at dark magnetic flux tubes?

If $J(M^4)$ (or rather $J(CD)$) leads to charge separation, the obvious idea is that charge separation could be also behind matter antimatter asymmetry.

1. I worked long time ago a model for large scale voids as extremals of Kähler action [21, 23]. The idea was that Kähler force due to the induced $CP_2$ Kähler form drives fermions to the boundaries of large voids and antifermions to "big" cosmic strings going through the void. The same could take place in all scales. In particular, cosmic strings containing galaxies as pearls in string would contain dark matter in super-conducting or superfluid state or its analog based on many-sheeted fermion states made possible by the covering structure of the space-time surface.

2. A modification of model would be based on $J(M^4)$ having opposite couplings to fermions and antifermions. Quantum classical correspondence (QCC) demands that $U(1)$ charge $F$ corresponds to the difference $F = B - L$ of baryon and lepton numbers so that its average density can vanish separately for matter and antimatter since proton and electron have opposite $U(1)$ charges. Above it has been assumed that the classical $U(1)$ forces is accompanied by a quantal force. The estimate for the $U(1)$ coupling strength as $\alpha_1 = R^2(S^2)^2/R^2(CP_2) = l_P^2/4\pi^2R^2$ was deduced is consistent with CP breaking in K system and matter antimatter symmetry.

3. Could the dark antimatter at the cosmic string serve as a source of a radial $U(1)$ force as Maxwellian intuition would suggests? It indeed seems natural to assign to a given flux carrying $U(1)$ flux tube opposite $U(1)$ charges - fermion numbers - at the ends of the flux tube. The average flux for the induced $U(1)$ electric field corresponds to that for $U(1)$ charged string in Maxwellian theory. The density of $F = B - L$ could vanish separately for matter and antimatter so that no radial force is generated.

4. Antimatter could be a macroscopic quantum phase with $h_{eff}/h = n$ at flux tubes or even as Cooper pairs whose members are located at parallel flux tubes. For instance, long flux tubes which look like highly flattened squares could be considered. In this case the magnetic fluxes would be antiparallel and have identical magnitudes. Cooper pairs would have spin zero. They could however rotate around the magnetic axis inside flux tube and also around the closed flux tube and therefore have net angular momentum.

5. The "big" cosmic string proposed to go through the large voids would create a transversal gravitational $1/\rho$ force proportional to string tension and the matter at the boundaries of void rotates with velocity that does not depend on $\rho$. At the level of many-sheeted space-time gravitational force is mediated by gravitational flux along the radial flux tubes orthogonal to the axis of "big" cosmic string. If there is $U(1)$ force associated with these flux tubes, it means $1/\rho$ repulsive force tending to reduce gravitational force but not changing its form predicting flat velocity spectrum. One can of course $U(1)$ force appearing in the field equations for preferred extremals as generalization of corresponding force for point like particles relates to the accelerated expansion. One could imagine also a tesselation of hyperboloid of $M^4_+$ by cells having void as unit cell.

## 4.2 What could be the mechanism of matter antimatter separation and B-L separation?

Basic idea is that matter antimatter asymmetry is local so that the amounts of matter and antimatter are identical in all scales and only the locations of matter and antimatter in many-sheeted space-time are different and antimatter is dark in TGD sense. $CP$ violation caused by $J(CD)$ could indeed imply that antimatter is dark and resides inside long flux tubes where as most matter is outside the flux tubes.

B-L separation is an analog of chiral separation effect (CSE) in hadron physics can be considered. $M^4$-chiralities would be replaced by $H$-chiralities in the TGD counterpart for magnetic separation effect (MSE) of QCD [30]. Pollack effect [27] involving separation of negative and positive charges in water in presence of gel phase and energy feeded by say infrared radiation gives rise electron-proton separation, which is a special case of B-L separation. Protons would become dark and go to the magnetic flux tubes. This mechanism has become basic mechanism of TGD inspired quantum biology and could explain the formation of negatively charged regions such as DNA and cell.

Matter antimatter separation would correspond to $F - \bar{F}$ separation. Some fraction of antimatter would go to magnetic flux tubes as dark matter and the rest would annihilate with ordinary matter.

### 4.2.1 Reconnections of flux tubes as a basic mechanism for matter antimatter separation?

The decay of flux tube energy to elementary particles in the reconnections of flux tubes create antimatter and matter and part of antimatter goes to flux tubes. Outside the flux tubes annihilation takes place and leaves a small fraction of matter: the fraction is about $10^{-10}$ and is for $l_P = 2\pi \times R(S^2)$ the same order of magnitude as $\alpha_1 = R(S^2)/R^2(CP_2) = (1/4\pi^2) \times l_P^2 \simeq 3 \times 10^{-11}$. For $g_1 = \sqrt{4\pi \times \alpha_1}$ one would obtain $g_1 \simeq 6.9 \times 10^{-5}$, which is of the order as Jarlskog parameter for K system. These numbers look rather realistic.

Reconnection could take in many manners. One possibility is inspired by the model of elementary particle in which particle is a pair of flux tubes with opposite fluxes at parallel space-time sheets having wormhole contacts at its ends. The projection of the flux tube to either sheet would be an open string. One can imagine that the flux tube shortens as short pieces split from it and decay to particles of matter with slightly larger probability than to antimatter. Could some particles go to flux tubes as dark antimatter and could some particles remain outside as matter. Annihilation would leave some antimatter inside and some matter outside.

#### 4.2.2 Could flux tube networks lead to matter antimatter separation?

The idea about flux tube network [29] would suggest a network of $U(1)$ flux tubes connecting nodes, which have non-vanishing $F$. Given flux tube could be of type $B-L$, $\overline{B}-\overline{L}$, $\overline{B}-B$ or $\overline{L}-L$. The annihilation of fermions and antifermions would delete by flux tube contraction links $\overline{B}-B$ and $\overline{L}-L$ and tend to annihilate matter and antimatter but not links $B-L$ because $B$ and $L$ are separately conserved in TGD Universe.

The reconnection of $\overline{B}-B$ and $L-\overline{L}$ bonds is not present in the ordinary kinetics and would transform matter-antimatter bonds $\overline{B}-B$ or $\overline{L}-L$ to $B-L$ and $\overline{B}-\overline{L}$ and vice versa and could reduce the number of bonds between antimatter and matter. Matter antimatter separation would take place if the process leads to disjoint networks having only $B-L$ bonds and $\overline{B}-\overline{L}$ bonds and vanishing total $B-L$ remain from the process. Due to $CP$ breaking these networks could have different space-time realizations.

The network would have layers corresponding to various values of $h_{eff}/h=n$ and the phase transitions changing $n$ would be possible at quantum criticality. Antimatter would correspond to $n>1$ phase.

### 4.3 TGD based model for the generation of galaxies

TGD view assigns dark matter/energy with long flux tubes having galaxies along them like pearls in necklace.

Consider first the view about disk galaxies.

1. After annihilation a fraction of antimatter remains the flux tube as dark matter and a fraction of matter survives outside the flux tube. Antimatter forms Bose-Einstein condensate like state and begins to rotate quantum coherently in the magnetic field in the same direction. Antileptons and antibaryons could have opposite rotation directions but baryonic angular momentum dominates if the rotation velocities are of same orer because the baryonic mass scale is higher. TGD inspired model of high Tc super-conductivity encourages to consider also pairs of flux tube helices analogous to DNA double strands.

2. Angular momentum conservation induces the rotation of ordinary matter. This would generate both matter antimatter asymmetry and opposite net angular momenta of matter and antimatter. This mechanism would in all scales and one can imagine that there are flux tubes having groups of galaxies around them like pearls in string. One would have fractal structure.

   For the particles of galactic matter the scale of angular momentum $m_{ord}R_{ord}^2\omega_{ord}$ would be much larger than for antimatter particles. The length $L_D$ of flux tubes per single galaxy would compensate for the small radius $R_D$ of rotational orbit. The condition that total angular momenta and masses are identical for matter and antimatter gives the condition $v_D/v_{ord}=R_{ord}/R_D>1$ relating that orbital radii and velocities of dark and ordinary matter. This would give $\omega_D/\omega_{ord}=R_D^2/R_{ord}^2$. Dark matter would rotate rather fast but not faster than light-velocity: this gives $v_D=(R_{ord}/R_D)\times v_{ord}<1$. The condition that dark mass per single galaxy is same as galaxy mass gives $(dm_D/dL)L_D=m_{ord}$.

Elliptic galaxies consist of old stars. They do not rotate appreciably and their rotation curve is declining.

1. Some fraction of ellipticals could have been formed in the collisions of disk galaxies as centrifugal forces throw out pieces of matter like droplets of water from a rotating umbrella. They would not bind to flux tubes anymore so that would not spin [34] and the rotation curve would be declining. The old stars in ellipticals would have originated from spiral galaxies.

2. Elliptical might be also formed in the decay of closed cosmic strings to matter and antimatter by the proposed mechanism. Local decay to matter and antimatter could result if there is a helical structure formed by two flux tubes analogous to a closed DNA double strand. The reconnection of the strands could give rise to a local generation of matter. Since the flux tube is closed, one expects that the net angular momentum of dark matter inside must be orthogonal to the plane of the flux tube. The angular momentum of ordinary matter forming the elliptic galaxy would be opposite so that it would not spin but rotate around the flux tube in direction opposite to that of antimatter.

   These elliptic galaxies might be the pearls, which can condense around long flux tubes. The gravitational field of the flux tube is in transverse direction and would force the elliptical galaxy to rotate, flatten to disk (also Earth is a little bit flattened by rotation), and give flat rotation curve asymptotically.

One can imagine variants of this model but the basic ideas remain the same.

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