

Solar Surprise

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Abstract

The detection of gamma rays from Sun has yielded a surprises. There are 5 times more gamma rays than expected and the spectrum has a deep and narrow dip around 30-50 GeV. Spectrum continues to much higher energies than expected, at least up to 100 GeV. One proposal is that there could be dark matter in the interior of Sun yielding the gamma rays but is unclear how they could get to the surface without experiencing the same fate as ordinary gammas from nuclear reactions. The findings provide a test bench for TGD based view about magnetic fields and the first challenge is to understand the solar cycle. The model is follows from the model for the formation of galaxies, stars, and planets as tangles of long cosmic strings thickened to flux tube. Wormhole magnetic fields correspond to closed flux tubes with monopole flux returning along different sheet. If M^4 projections of the sheets co-incide and test particle touching them experiences no net magnetic force but the energy of flux tubes is dark making itself visible through gravitational fields. For disjoint projections sheets carry measurable magnetic fields. Polarization reversal could be understood as a quantum analog of spontaneous magnetization generating first dipole loops of type II (I) taking measured B to zero. After this dipole loops of type I (II) would split by reconnection and decay to smaller loops and leave Sun. This defines first half-cycle and for second half-cycle the roles of loops are changed. The model discussed explains qualitatively the findings in terms of cosmic rays entering to the flux tubes of dipole fields and accelerated in the electric field of the closed flux tube and making possibly several cycles before being detected. This predicts band structure of the spectrum. The model suggests also inversion in cylindrical coordinates as an approximate Z_2 symmetry mapping to each other the flux tube portions in the interior and exterior of the dipole core. Inversion symmetry is also a symmetry of Maxwell's equations. The notions of of monopole flux tube and associated approximate Z_2 symmetry acting either as reflection or inversion could be universal. Z_2 can be also represented as a subgroup of the group of Galois symmetries predicted by adelic physics. This picture leads to highly non-trivial predictions. For instance, the "Axis of Evil" anomaly of CMB can be understood. For instance, quantum correlations in cosmological scales explain why the plane of planetary system makes itself visible in CMB. One can also add highly non-trivial detail to the TGD inspired view about quantum biology and consciousness.

1 Introduction

Sabine Hossenfelder gave a link to a popular article (see <http://tinyurl.com/y6mpuggu>) telling about rather shocking new findings about Sun. There are 5 times more gamma rays than expected and the spectrum has a deep and narrow dip in 30-50 GeV range. Spectrum continues to much higher energies than expected, at least up to 100 GeV. One proposal is that there could be dark matter in the interior of Sun yielding the gamma rays but is unclear how they could get to the surface without experiencing the same fate as the ordinary gammas from nuclear reactions.

There is also a correlation with sunspot cycle (see <http://tinyurl.com/aqw2hmz>). Basic data and observations related to correlations with the solar cycle are described in the article [2] (see <http://tinyurl.com/yxajyzp8> and [1] (see <http://tinyurl.com/y2qlaaa2>).

1. Power law spectrum is harder than for cosmic rays: spectral indices are $n = -2.2$ and $n = -2.7$ respectively (one has power law behavior E^n for the flux). The spectral intensity at 100 GeV is very nearly the maximum flux predicted by the model assuming that reflection of cosmic gamma rays explains the gammas.

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2. The spectrum has two components: poloidal component farther from equator and equatorial component largest during sunspot minimum. The equatorial contribution is maximal at solar minimum. The spectral index of the equatorial contribution is harder and higher energies are present. The energy range is maximal during spot minima. Gamma flux is reduced during sun spot maxima.

How the observed gamma rays could be produced in TGD Universe?

1. Gamma rays cannot be produced by nuclear reactions as ordinary gammas since nuclear energy scale is much below the scale of gamma rays extending to 100 GeV at least. Even the hadronic energy scale is too low. The gamma rays could be cosmic rays having already high energies: the spectral indices are however different. This leaves acceleration of charged particles producing gamma rays as the most plausible mechanism irrespective of whether the charged particles come from solar core or are cosmic rays.
2. Dark magnetic flux tubes are basic notion of TGD and could serve as the channels along which charged particles could propagate to the surface without losing their energies in collisions. An interesting hypothesis considered already earlier is that solar magnetic field are what I call wormhole magnetic fields [14] consisting of closed monopole flux tubes with flux and return flux at different space-time sheets connected by tiny wormhole contacts. This would predict that the flow is not evenly distributed but reflects the structure of the flux tube distribution. If the flux tubes have same M^4 projection they cause no effects on test particle and behave like dark energy creating only long range gravitational fields.

Charged particles could accelerate in the electric field of flux tube as they travel along flux tubes and generate gamma rays by some mechanism. The energy would be the increment of Coulomb energy if dissipation is neglected. A simple modification of flux tube type extremals allows the presence of helical magnetic and electric fields along flux tube orthogonal to each other. I have proposed the same mechanism to explain the gamma rays and high energy electrons at MeV energies associated with lightnings [4]: in standard physics framework dissipative losses do not allow them.

3. What could be the production mechanism of gamma rays? If flux tubes have sharp kinks, charged particles should experience large deceleration in the kinks and could emit high energy gamma ray in the process. The highly relativistic charge particle itself could leak out (one cannot exclude nuclei from solar core). Large deflection angles however requires transfer of momentum also to flux tube degrees of freedom.
4. What could be the origin of the dip around 30-50 GeV? If the acceleration takes place in the electric fields assignable to the closed flux tubes assignable to solar dipolar magnetic field, the charged particle could travel several times around the loop giving rise to several energy bands explaining the gap and suggesting several of them. The flux loop would act as a particle accelerator.
5. The charged particles could be provided by the solar core or they could be cosmic rays. The order of magnitude for gamma ray intensity is 5 times larger than in cosmic ray model, which encourages the identification as cosmic rays (see <http://tinyurl.com/psdp99h>). The origin of cosmic rays is however also a mystery and neutron stars, supernovae, active galactic nuclei, quasars, and gamma-ray bursts have been proposed as sources of cosmic rays.

A possible mechanism producing cosmic rays could be pair-annihilation of pairs of M_{89} pions with mass about 70 GeV [12] to gamma ray pairs or charged particles with energies 35 MeV. Could the dip observed in the energy range around 30-50 GeV somehow relate to the charged decay products of M_{89} pions accelerating in the electric fields of flux tubes? Could the dip be gap without the decays of M_{89} pions?

In TGD the model for the formation of galaxies, quasars, and active galactic nuclei, and even stars, and planets relies on the formation of looped tangles along long thickening cosmic strings with

topology resembling that of dipole magnetic field. Galactic matter would be produced by the decay of the flux tube energy to particles as analog of the decay of inflaton field. This could generate both charged particles and gamma radiation in the solar core and in neutron stars. The acceleration could be much more effective due to the strong magnetic and electric fields involved. Also charged particles can leak out from the flux tubes and cosmic rays could be produced by this mechanism. Cosmic rays could move along the highways defined by the long magnetic flux tubes connecting galaxies.

The understanding of the correlations with the solar cycle requires a model for the polarization flip. One can consider several options but the model based on reconnection splitting dipole loops from the flux tube tangle representing the analog dipole field is the simplest one. The simplest variant of the model requires zero energy ontology (ZEO) and quantum coherence at dark flux tubes in solar length scales and that long galactic string defines wormhole magnetic field with two sheets (type I and II) connected by wormhole contacts separated from each other in the sense that M^4 projections are disjoint.

1. Let us denote the numbers of dipole loops of type $i = I, II$ by n_i . Assume that in the initial situation one has $(n_I = n_{max}, n_{II} = 0)$. B as maximum value B_{max} . The arrows of time at the two sheets are assumed to be opposite during cycles.
2. The transition leading $B = B_{max}$ to $B = 0$ would be "big" state function reduction (BSR) changing the arrow of time at sheets of both type I and II. BSR would generate maximum number of new dipole flux loops of type II: $n_{II} \rightarrow n_{max}$ so that one has $n_I = n_{II} = n_{max}$ and $B = 0$.
3. After that dipole loops of type I begin to split away by reconnections in "small" state function reductions (SSRs) so that n_I decreases. They split further in pieces and leak out from Sun whereas n_{II} remains unchanged since it corresponds to the passive boundary of CD - this is essential. Net B increases until one has $B = -B_{max}$.
4. Next occurs BSR generating maximum number of new flux loop portions of type I leading $n_I = n_{II} = n_{max}$ and $B = 0$ and same is repeated except that now n_{II} decreases.
5. One can understand the sunspot cycle in terms of split dipole loops leaving the Sun: their intersection with the solar surface would define sunspot pair and the distance of members of the pair would decrease to zero during the cycle.

The model leads to rather dramatic predictions.

1. Various magnetic structures are predicted to appear in pairs with members related by an approximate Z_2 symmetry mapping to each other the flux tube portions inside and outside dipole core. Inversion symmetry is also a symmetry of Maxwell's equations. Also reflection symmetry can correspond to Z_2 . This symmetry should be universal and the predictions are in sharp contrast with the locality principle of classical physics. One could even understand the mysterious "Axis of Evil" associated as anomaly of CMB and apparently giving special role for solar system (see <http://tinyurl.com/yb6nabw4>).
2. Also unexpected connections with TGD inspired views about biology and consciousness emerge. Magnetic body (MB) is the intentional agent in living system Z_2 realized as inversion could related the parts of MB in the interior and exterior of Earth's dipole core: could the idea about intra-terrestrial life introduced originally half-jokingly [9, 10, 6, 6] make sense - at the level of MBs at least? ZEO based theory of consciousness predicts that conscious entities can have both arrows of time and death means reincarnation with opposite arrow of time. But where do these ghostly selves with opposite arrow of time reside? Could Z_2 - possibly realized as inversion - relate these selves to each other.

2 TGD based model for the solar magnetic field, solar cycle, and gamma ray emission

An attempt to understand the situation in TGD framework. One can of course consider several alternative models but the constraints from solar spot cycle and observation exclude most proposals. The following proposal seems to survive the most obvious killer arguments.

2.1 How the magnetic fields of galaxies and stars are generated?

To get a general enough perspective about the generation of time dependent B , one must consider the general model for how the magnetic fields of galaxies, stars, and planets are generated.

1. The magnetic fields of galaxies, stars, and planets would have formed as tangles along cosmic strings thickened to magnetic flux tubes carrying monopole flux. . Tangles would be formed by the flux tubes forming knotty structures with flux tubes defining analog for subset of flux lines of dipole field. The flux tubes can organize in several manners.

Cosmic strings would be wormhole magnetic fields carrying opposite monopole fluxes at space-time sheets connected by wormhole contacts (in principle it is possible to consider also single-sheeted monopole fluxes). I will talk about sheets of type I and II. If the flux tubes are on top of each other in the sense that M^4 projections are identical, the magnetic field experienced by test particle touching both flux tubes would vanish. The fact that the energy of the flux tubes gives rise to gravitational field can be used to argue that one can talk about dark energy in this case. The flux tubes can be connected by extremely short wormhole contacts at places, where they are on top of each other. If the Euclidian wormhole contacts can have tube-like M^4 projection, they would be also flux tube like.

2. It is not clear whether the flux tubes of both type I and II are inside the volume bounded by Earth's B or whether second type of flux tubes are outside Earth. This gives rise to several options for how B can be realized as flux tube field and how the time dependence of B is obtained.
3. One can imagine two options, which apply to both types of fluxes separately. For the most general option (Option I) the incoming flux tube can divide to smaller flux tubes going both to the interior and exterior of the dipole core. The extreme options (Option II and III) are that it flows entirely to the dipole core or divides to flux tubes travelling outside the dipole core (this situation is analogous to hydrodynamical flow past obstacle). It will be found that option II is most attractive one.
4. Incoming flux long tube at given sheet forms a tangle. Consider first the tangle formed by the incoming long flux tube of given type at fixed space-time sheet, for definiteness restriction the consideration to flux of type I.
 - (a) For Option I the neighbouring flux portions of the flux tube portions inside and outside dipole core can have random orientations: this would be like random spin system without any magnetization. The average observed field would be random. For Options II and III this kind of situation is not possible.
 - (b) The flux tube in the tangle can also arrange like spins in spontaneous magnetization so that neighboring portions of the flux tube are parallel both inside the core and outside it. The flux and return flux would be at different sides of the dipole core. This could give rise to an analog of say dipole field. For instance, dipole core could correspond to a spherical volume bounded by the Earth's surface. The extreme situation would correspond to Option II or III.
5. For Option I the polarity of observed B could be due to a process analogous to spontaneous magnetization, whose degree can vary. The degree of magnetization would be determined by the ratio

of the incoming fluxes going to the interior and exterior of the dipole core. The total flux Φ flowing inside dipole core is $\Phi = (p_1 - p_2)\Phi_{in}$, where p_i are the fractions of incoming fluxes going inside the dipole core and outside it. If the ratio equals to unity the net B vanishes in long enough scales. For Options II and III one cannot have time varying B unless the number n_i , $i \in \{I, III\}$ of dipole loops can vary.

Polarization reversal could be a dynamical process. For the analog of hydrodynamical flow the portions of the flow going through the dipole core and its exterior could change, and the fraction of these portions is the parameter determining the strength B . Oscillating B would mean oscillation of this fraction. Also the numbers n_i change and induce change of B .

6. If the flux tubes of both types are in the volume carrying B , more possibilities arise for Option I since the flux tube portions of type I and III can have magnetizations of varying degree and these can be parallel or opposite inside (outside) dipole core.
7. For Options II and III the magnetization direction cannot vary unless n_i can change and the total average magnetic field would vanish for $n_I = n_{III}$. n_i can however change if dipole loops split away by reconnection. It turns out that option II is the most promising one.

2.2 A model of solar magnetic field in terms of monopole flux tubes

The model relies on the notion wormhole magnetic field with flux tubes carrying electric fields, the notion of reconnection, and the theory of quantum measurement based on zero energy ontology [15] and extending to a theory of consciousness[21].

Also hydrodynamic analogy, the analogies with ferromagnetic hysteresis cycle, spontaneous magnetization, and de-magnetization, the analogy with the Meissner effect explaining solar spots as magnetic flux branching from the dipole axis of solar magnetic field, and Lenz principle (induction law) stating that magnetic field generates ohmic current in turn generating magnetic field opposing the change of the magnetic field, are used as guidelines.

1. One can argue that the magnetic fields in question correspond to flux tube portions carrying monopole flux. The empirical support for the hypothesis comes from the fact that monopole fluxes need no currents to generate them. Cosmology is indeed full of long range magnetic fields whose presence is mystery in Maxwellian electrodynamics.
2. Interaction of two kinds of magnetic fields would be involved. The first magnetic field identified as solar magnetic field, call it B , is assumed to have flux tubes wormhole magnetic field carrying monopole fluxes. No current is needed to create the magnetic flux: something impossible for ordinary Maxwellian fields. Note also that the cross section of flux tube is closed 2-D surface. One could call B topological magnetic field. Mathematically B could be seen as an analog of the external magnetic field H generating as a response total magnetic field as a sum of H and magnetization M .

Second magnetic field, call it B_1 would be Maxwellian and generated by Faraday induction. By Lenz principle it opposes the change of the magnetic flux associated with B and has roughly the same direction. B_1 would correspond to M . In the proposed framework the induced currents j would generate B_1 and it would be regarded as secondary rather than primary field.

Remark: The flux tubes of B_1 would be obtained from closed string like objects with CP_2 projection which geodesic sphere S^2 by replacing S^2 with disk D^2 , by deforming to get flux tube, and gluing it to a large background space-time sheet along D^2 . The current creating B_1 would be associated with the boundary of D^2 .

One cannot of course exclude the Maxwellian option for B .

1. The portion of flux tubes of B identifiable as analog of the dipole core of Maxwellian dipole field would consist of particles with magnetic moment whereas for monopole flux no magnetic moment is needed. Magnetic moment could be due to spin or orbitals motion.

Remark: One could wonder whether quantum-classical correspondence (QCC) requires that the monopole flux has as quantum counterpart magnetization representable in terms of fermions.

2. The contribution of the spin to magnetic field is rather small so that the idea about spontaneous magnetization at flux tubes defining dipole does not look promising. Note however that the large value of h_{eff} together with proportionality of $\mu \propto \hbar_{eff}/m$ could change the situation. Macroscopic quantum coherence making possible quantum states with macroscopic radius for the orbits could be considered and would conform with the idea that the flow of currents generates B . B could be of course generated also classically.

2.3 Are wormhole magnetic fields really needed?

The additional assumption is that wormhole magnetic fields involving two space-time sheets connected by wormhole contacts appear in the volume containing B . More generally, fundamental magnetic fields would be wormhole magnetic fields. This additional hypothesis is necessary in the recent model of elementary particles and p-adic fractality suggests that the property holds true also astrophysical scales.

1. In elementary particle scales monopole flux tubes associated with wormhole magnetic fields must be closed and involve return flux along second space-time sheet. If the two space-time sheets have same M^4 projection, the test particle touches both sheets and experiences essentially no gauge fields. At QFT limit one would have no fields. Therefore the M^4 projections of the flux tubes at the two sheets must be disjoint in order that one has normal magnetic field in operational sense.

The energies of both flux tubes however sum up and the wormhole flux tube pair has long range gravitational interactions. The attractive interpretation is that if the volumes in which the sheets have same M^4 projection, the energy of flux tube pair corresponds to dark energy. The portions giving rise to tangles in which the flux sheets have separate projections give rise to ordinary matter. This would give rise to galaxies, stars, and planets and even smaller objects in various scales. Flux tubes would thicken and their energy would decay to ordinary and dark matter.

2. Wormhole magnetic fields could define pairs of systems. The understanding of the geometric correlates for the hierarchy of Planck constants have already led to the realization that many-sheeted space-time means that one space-time surface can be regarded as n_1 -fold covering of CP_2 and n_2 -fold covering of M^4 such that one has $h_{eff}/h_0 = n = n_1 n_2$ holds true. For n_1 -fold covering of CP_2 the sheets can be disjoint regions of M^4 . Although the regions are disjoint, they are physically closely correlated. This is classical correlate for macroscopic quantum coherence coded also by the large value of n .

For $n_1 = 2$ one obtains the simplest pairs. Also even values of $n_1 = 2m_1$ are of course and would describe a pair of structures with m_1 components. The components would be most naturally flux tubes fusing to larger flux tube fractally.

3. This view becomes understandable if one takes CP_2 coordinates or $M^2 \times CP_2$ coordinates as a coordinate system so that the roles of space-time and fields are changed or partially changed. At the level of wormhole contacts the change of the roles of M^4 and CP_2 is necessary. For string like objects $M^2 \times S^2$ replaces M^4 . This corresponds to that part of TGD, which does not allow description in terms of GRT.

Playing with the ideas generates questions and new ideas, not always realistic. At this time the question is following.

1. Could the Euclidian region associated with wormhole contact and connecting wormhole throats at the two sheets connect two disjoint, even distant regions of M^4 ? If so, the wormhole contact would be analogous to Einstein-Rosen bridge except that it has Euclidian signature of the induced metric.

Could one identify the wormhole contact as a space-time correlate for entanglement or prerequisite for it? There would be no signal involved since in Euclidian space-time regions one cannot talk about propagation. Euclidian flux tubes are in central role in p-adic mass calculations [11] but they are extremely short.

I have assumed that time-like flux tubes can serve as correlates of entanglement. Could one think that Minkowskian flux tubes would allow classical signalling and Euclidian flux tubes would serve as classical correlates for entanglement. Could both aspects be involved with quantum communications?

Remark: One can obtain Euclidian space-time region from piece of M^4 by performing a large enough deformation in CP_2 directions and also this could give rise to Euclidian induced metric. One can also have cosmic string with piece of M^2 as string world sheet and deformed such that one has flat E^2 . The deformation of this string world sheet would represent Euclidian flux tube.

2. Here one must be however extremely cautious. Hitherto I have regarded shortness of flux tubes as obvious, and might have been right. One cannot however exclude the possibility that also Euclidian wormhole contacts are involved but they do not seem to be necessary: one could have wormhole magnetic fields with wormhole contacts only in the regions where M^4 projections overlap. All depends on the properties of preferred extremals.

2.4 How to understand the solar cycle?

Sunspot cycle (see <http://tinyurl.com/y2qlaaa2>) has period of 22 years and consists of two 11 year half-periods during which opposite polarity of B . The understanding of the mechanism causing the flip of the polarity looks the most difficult part of the problem - at least from TGD point of view. Each half cycle starts from a situation in which the dipole part of B vanishes and sunspots appear at opposite sides of equator at symmetrically related positions at mid-latitudes (about 30 degrees from equator).

Sunspots (see <http://tinyurl.com/y2qlaaa2>) carry intense magnetic fields (fields strength is about 2 Tesla in the vicinity of Sunspot according to Wikipedia) and they have lower temperature than surroundings due to the magnetic pressure. During the half-cycle Sunspots drift towards equator and maintain their polarity. The diagrammatic description of the time evolution at the solar surfaces is known as butterfly diagram. The natural interpretation is that the sunspots at opposite sides are connected by flux loops.

During the cycle the dipole field with opposite polarity as compared to previous cycle is generated and towards the end of the cycle there is a period in which no sun-spots are observed: they would be near equator if present. The spots could be present but the density of elementary flux tubes could be too low to give rise to average field strength enough to cause an observable reduction of temperature.

2.4.1 Polarity reversal of B

What could be behind polarity reversal. First some guiding ideas.

1. An analogy with ferromagnetic hysteresis circuit suggests itself. B generates B_1 having opposite direction. When the value of B_1 is critical it induces a phase transition in which the direction of Kähler flux is changed at flux tubes. Second half of the 22 year sunspot cycle would start. The ohmic current j generated by B would change and this would induce the magnetic turbulence accompanying solar spots.

This analogy is not quite complete since the generation of B with opposite sign occurs slowly whereas the vanishing of magnetic field is a fast process. De-magnetizing phase transitions seem therefore a natural analog for the disappearance of B .

2. What the analog of spin flip means is highly non-trivial question when the size of the analog of spinning particle is of the size scale of Sun. Quantal and topological effects in solar scales could be in question and involve both TGD view about space-time and fields as well as hierarchy of Planck constants as description of dark matter. The model to be described in the sequel applies universally in TGD Universe and leads to quite dramatic and testable implications.

Consider next general TGD inspired ideas relating to the change of the polarity of B in TGD framework. A general model based on the formation of flux tube tangle as a representation of the say dipole field looks like a safe starting point and provides also a general model for the change of the polarity. An essential element is the distribution of incoming flux of long cosmic string like object to fluxes going through the interior and exterior of the dipole core and return back through exterior and interior. The fractions going through interior and exterior determine the strength of observed B . Whether both kinds of flux tubes are present or not, depends on model.

The first model, call it Model I, is classical. Now one could do using only single flux tube type, say type I, which however must divide to flux tubes travelling both inside and outside the dipole core.

1. The decay of B would correspond to option I involving the change of fractions p_1 and $p_2 = 1 - p_1$ of the flux tube portions going through the dipole core reducing the parameter $p_1 - p_2$ to zero. The permutations of flux tube portions inside and outside core must lead to $p_1 - p_2 = 0$ and one expects that this process continues and changes the sign of $p_1 - p_2$ and therefore induce polarization reversal. The duration of the process taking $p_1 - p_2$ to zero is rather short as compared to the duration of the half-cycle. The duration of the sunspot minimum is about 10 per cent of that for the entire half cycle. In the hydrodynamical analogy the process would be redistribution of the incoming flow and could be modelled phenomenologically as a change of flow resistances associated with the two channels involved.
2. This model does not involve reconnection process and does not provide any obvious explanation for the appearance of sunspots nor for the reconnection process associated with the reversal of the polarization of B . Therefore Model I is not promising.

Second model, call it Model II, is quantum mechanical and involves ZEO in an essential manner and one could assume that incoming flux tube enters to the dipole core entirely (option II).

1. Dipole winding number n_i characterizes the situation for a given type of flux tube. The larger the value of n_i , the larger the dipole strength. n_i could change by reconnection process in which entire dipole loop reconnects and snips away. This followed by further splitting to flux loops would correspond to the emission of magnetic loops from the Sun.

The opposite process would correspond to a fusion of flux loop with a long flux loop but looks thermodynamically implausible. Also a fusion of a short flux loop with long flux loop and the growth of the reconnected part to large dipole loop looks implausible.

2. Could ZEO based quantum TGD allowing temporary time reversals come in rescue? At dark space-time sheets one can indeed imagine the possibility of time reversals. Ordinary matter would be controlled by dark matter with larger value of $h_{eff}/h_0 = n$ serving as an IQ in TGD inspired theory of consciousness, and would be forced to follow the leader in conflict with its thermodynamical instincts. Could the process involve "big" state function reduction (BSR) and could the dominance of flux tubes of type I and II correspond to different arrows of time at the level of dark flux tubes? Reconnections for flux loops of say type II would occur in time direction opposite to the standard direction of time but second law would hold true in generalized sense.

3. The simplest option is that all incoming flux enters to the interior of the dipole core ($p_{2,I} = 0$ identically) or to its exterior ($p_{1,I} = 0$) identically. The first looks more plausible. The integers $n_i, i = \{I, II\}$ characterize the numbers of dipole flux loops carrying magnetic fields with opposite polarizations. Dipole strength is proportional to $n_I - n_{II}$. The arrows of time at the two sheets are assumed to be opposite for flux tube of type I and II.
4. Consider now a model for the the first half-cycle.

- (a) Assume for definiteness that in the initial situation one has ($n_I = n_{max}, n_{II} = 0$). B as maximum value B_{max} .
- (b) The transition leading $B = B_{max}$ to $B = 0$ would be "big" state function reduction (BSR) changing the arrow of time at sheets of both type I and II. BSR would generate maximum number of new dipole flux loops of type II: $n_{II} \rightarrow n_{max}$ so that one has $n_I = n_{II} = n_{max}$ and $B = 0$.

This transition is clearly a quantum analog of spontaneous magnetization in sector II. Could one say that a spontaneous magnetization already present in sector I induces opposite spontaneous magnetization in sector II?

Quantum classical correspondence (QCC) inspires the question about there is in the fermionic sector genuine spontaneous magnetization involving fermion spins. Could a formation cyclotron condensate of spin zero Cooper pairs with members at flux tubes of type I and II and having opposite spins accompany this process?

- (c) After that dipole loops of type I begin to split away by reconnections in "small" state function reductions (SSRs) so that n_I decreases. They split further in pieces and leak out from Sun. Net B increases until one has $B = -B_{max}$. This process is analogous to gradual decay of magnetization.
- (d) What looks strange that n_{II} would remains unchanged during this process. In ZEO this makes sense: it would corresponds to the passive boundary of causal diamond (CD). One would have two CDs having common portion of boundary, call it δCD . Since the arrows of time are opposite, $\delta CD \subset \delta CD_{II}$ would be passive and experience generalized Zeno effect whereas $\delta CD \subset \delta CD_I$ for CD_I would be active experiencing gradual decay of magnetization in the sequence of "small" state function reductions (SSRs).
- (e) Topologically one can understand the sunspot cycle in terms of split dipole loops leaving the Sun: their intersection with the solar surface would define sunspot pair and the distance of members of the pair would decrease to zero during the cycle.

5. The model for the second half-cycle is identical. First occurs BSR generating maximum number of new flux loop portions of type I leading $n_I = n_{II} = n_{max}$ and $B = 0$ and same is repeated except that now n_{II} decreases.

The classically highly counter-intuitive aspect of this picture is that dipole loops would appear in BSR as quantum leap in astrophysical scales. There would be no continuous time evolution generating additional dipole loops. Their dis-appearance by reconnections would correspond to classical time evolution. If one performs time reversal for thermodynamic intuition, there is nothing mystical involved.

Model II looks to me more promising -if not even the only possibility - although conservative colleague can criticize it for the speculative new physics features: these features are however basic elements of new physics predicted by TGD.

2.4.2 Sunspots as intersections of split dipole flux loops with the Earth's surface?

How could sunspots be understood in the picture suggested by Model II?

1. BSR would induce the cancellation of B . Sunspots should emerge after the cancellation and serve as a signature of BSR inducing change of the arrow of time at flux tube space-time sheets. The usual statement is that the density of the elementary flux tubes composing the the split flux loop is high enough the average magnetic pressure lowers the temperature so much that the solar spot becomes visible.

Could the local reduction of temperature inside sunspots, something not expected in the naive thermodynamical thinking be forced by the change of the arrow of time at dark flux tubes? One would have leveling of temperature differences but in opposite time direction induced by dark flux tubes having arrow of time opposite to the standard one: by dark flux tubes of type I during first half-cycle and flux tubes of type II during second half-cycle.

2. The appearance of sunspots would relate naturally to the reconnection process leading to the disappearance of the dipole loops Do the snapped flux loops, which can split further to pieces eventually leaving Sun, intersect its surface at the sunspots so that the formation of sunspot and its disappearance would correspond to a splitting of closed dipole loop by reconnection and further splitting to smaller loops.

The motion of sunspots towards equator would correspond to the outwards motion of the split flux dipole loop and solar spots would represent its intersection with solar surface. This also explains why the number of sunspots is gradually reduced during the half-cycle.

3. The fact that sunspots emerge first at latitudes $\pm\pi/6$ means that the split dipole flux loop intersects Earth's surface at positions with distance $h = R_E/2$ from equator. Since the distance is reduced after that, the outward motion of the loop requires that dipole core has height smaller than R_E .

Also in the case of Earth's magnetic field an analogous quantum picture might apply [18] and solar spots might have "Earth spots" as magnetic anomalies. What is fascinating that the reversals of the Earth's magnetic field would be quantum processes in the scale of entire Earth and the magnetic field would go to zero instantaneously. What this means for living systems is an interesting question to ponder.

2.4.3 Does the polarity inversion involve spatial inversion?

Assume that the flux tubes correspond to monopole flux tube, which defines two-sheeted wormhole magnetic field. There is a strong temptation to assume that the members of the pairs defined by portions of flux tubes of given type (I or II) in the interior and exterior of dipole core are related by an approximate symmetry. If so, one would have doubles or mirror pairs of systems. What kind of symmetry polarity inversion for the solar B could correspond?

1. Assume that the two flux tube sheets of wormhole magnetic field have M^4 projections with empty intersection. Polarization reversal could permute the positions M^4 projections of the two sheets of flux tubes turning the direction of the magnetic flux. If the space-time surface representable as a map from CP_2 to M^4 , the flip could be understood as a reflection in CP_2 degrees of freedom permuting the M^4 images and represented also as a reflection or inversion in M^4 . In adelic physics [19, 20] Z_2 has interpretation as subgroup of Galois group.
2. Could the solar magnetic field be doublet structure mapped to itself under Z_2 ? The identification of the pair as being formed by symmetry related parts of the flux dipole tubes in the interior of dipole core and outside it is what comes naturally in mind. The symmetry could be realized as inversion with respect to the surface of the dipole core mapping inside and outside to each other. Inversions are indeed symmetries of Maxwell's theory, gauge theories, and of twistor Grassmannian approach. For a Maxwellian current rotating at the surface of infinitely long cylinder the magnetic field is constant differing in sign inside and outside the cylinder and invariant under inversion $\rho \rightarrow 1/\rho$. Also for $n_1 = 2m_1$ m_1 could correspond to a subgroup of CP_2 . One would have double of bundles formed from m_1 flux tubes: dipole flux tube consisting of m_1 elementary flux tubes.

3. The symmetry involved need not always be inversion. It could be also spatial reflection. The possibility of higher values of $n = n_1 n_2$, $n_1 = 2m_1$ suggests the possibility of long range correlations between m_1 pairs in astrophysical scales manifesting themselves quite concretely.
4. The representability of the group permuting flux tubes as finite discrete subgroups of $SO(3)$ acting as symmetries of Platonic solids would be very natural, and one can ask whether the appearance of Platonic solids in biology reflects this. This might allow to get some idea about why icosahedral model of harmony in terms of Hamiltonian cycles leading to the notion of bio-harmony predicts correctly genetic code [25].

2.5 Trying to understand solar gamma ray spectrum in TGD Universe

One can try to understand the observations about gamma rays [2, 1] (see <http://tinyurl.com/yxajzyp8> and <http://tinyurl.com/y2qlaaa2>) in the proposed picture. Some kind of acceleration mechanism suggests itself strongly.

1. An electric field associated with flux tubes with helical magnetic field is the simplest option. TGD allows simple deformations of flux tube like solutions [8] in which Kähler magnetic and electric fields are orthogonal and helical and one can hope that they define preferred extremals.

What about the electric force experienced by a test particle when the flux tubes of type I and II having same M^4 projection? The identification these objects in terms of dark energy would suggest that also the net electric force cancels and this kind of flux tube pair serves as a kind of superconducting wire.

2. If the flux tubes and gamma rays are dark with large $h_{eff}/h_0 = n = n_1 n_2$, they can propagate without interactions with ordinary matter. The dissipation would be solely due to curvature, in particular the kinks of the flux tube but would not be present at rectilinear portions of the flux tube. Therefore the amount of dissipation would be small.

Forgetting the losses caused by the curvature of the flux tube, there would be maximum energy $E = ZeV$, V the voltage along flux tube section to which the particles such as protons can be accelerated, and this would define cutoff energy for the emitted gamma rays. I have proposed that this kind of model explains also the gamma rays associated with lightnings [4].

3. The dip in the spectrum suggests at least two energy scales for accelerated particles emitting gammas as brehmstrahlung and defining the endpoint of the brehmstrahlung spectrum. The explanation that comes in mind is that particles can go through several cycles of acceleration along closed dipole flux tubes and emit gamma rays at kinks. This would give rise to energy bands labelled by the number of acceleration cycle. The possibility of saturation looks plausible. One would have particle accelerator analogous to storage ring. What would be new as compared to LHC would be quantum coherence in the scale of accelerator. For the values of h_{eff} involved the dark particles would have Compton lengths of the order of the size of Sun.
4. How could the charged particle and gamma rays emerge from the flux tubes? One can start from everyday experience. Car can fall off the road in sharp curve. Now the sharp curve would correspond to a kink in flux tube. By momentum conservation there should be a large exchange of momentum with the flux tube to keep the charged particle at the flux tube and this is improbable for sharp kinks. Since the charged particles are relativistic and gamma rays must be directed to the observer, the change of momentum direction must be large. In any case, this requires a large exchange of momentum with the collective flux tubes degrees of freedom. It is quite possible that several gamma rays are emitted at the kink. The charged particle can also leak out.

A proper description of the situation might be in terms of dark cyclotron states. If the TGD view about dark matter as $h_{eff}/h_0 = n = n_1 n_2$ phases is true one can treat the bundle of flux tubes

as single quantum coherent entity. In particular, the solar spots could be identified as this kind of quantum coherent flux tube bundles and n_2 could correspond to the number of elementary flux tubes.

5. The sharp kinks appear at two places. Near the North pole where dipole field lines/flux tubes make a sharp kink. Due to differential rotation the flux tubes associated with the dipole contribution follow the rotation of equator and develop tentacles. The shape of strongly flattened square implies instability against splitting of the tentacles and decay to flux loops by reconnection. This part of the magnetic field decays and leads to magnetic turbulence. Also in the standard picture differential rotation is expected to induce reconnections of field lines. The kinks at the ends would induce emission of gammas and leakage of charged particles. Even single gamma ray could be enough.

Gamma radiation indeed has two components. Polar component is roughly constant and the equatorial component having sharp maximum during sunspot minimum.

Spectral index is different for the energy distributions for cosmic rays and gamma rays from Sun: solar distributions are harder. Also the equatorial distribution is harder than polar distribution. One expects that the distribution depends on the energy of the gamma ray and on the sharpness of the kink. In the case of polar distribution two gammas is minimum whereas for equatorial distribution single ray can be enough. This softens the polar distribution as compared to equatorial one. Since several loops are possible even the cosmic ray distribution for charged particles can harden.

Where could the charged particles originate?

1. The basic observation is that flux of gammas is 5 times higher than predicted by the model identifying them as cosmic rays reflected in solar magnetic field fails. Roughly the same order of magnitude suggests that cosmic gamma rays could be the origin. Spectral distribution does not support this idea.
2. Charged particles could come from the solar core or along the long thickened cosmic string continuing as flux tubes of the magnetic field. Cosmic string would not accelerate the charged particles but only feed in the particles beams as kind of supra currents. Also cosmic rays could enter the flux tubes as assumed in the original model: in fact, cosmic rays would naturally arrive along the long flux tubes connecting Sun to sources of cosmic rays.

This could explain why the upper bound for gamma ray energies for cosmic rays equals to the maximal detected energy (100 GeV). Instead of being reflected cosmic rays could rotate possibly several times around dipole flux tube and leak out in the kink. The emission of gamma rays at kinks reduces the energy gain for simple loop and for higher number of loops the reduction is larger. Saturation is quite possible.

3. The origin of galactic rays is still a mystery (see <http://tinyurl.com/psdp99h>). One proposal is that they originate from neutron stars. The proposed acceleration mechanism could be at work in the case of neutron stars so that neutron star could indeed provide the charged particles. As discussed there are also other options.

2.6 Empirical support for the confinement of radiation to monopole flux tubes

In the following some pieces of support for the confinement of radiation to closed monopole flux tubes are discussed. I learned about a very interesting result related to early cosmology and challenging the standard cosmology. The result is described in popular article "*Early opaque universe linked to galaxy scarcity*" (see <http://tinyurl.com/y74xe4jr>). The original article "*Evidence for Large-scale Fluctuations in the Metagalactic Ionizing Background Near Redshift Six*" of Becker et al [3] is published in *Astrophysical Journal* (see <http://tinyurl.com/y7ho454e>).

The abstract of the article is following.

"The observed scatter in intergalactic Ly α opacity at $z \leq 6$ requires large-scale fluctuations in the neutral fraction of the intergalactic medium (IGM) after the expected end of reionization. Post-reionization models that explain this scatter invoke fluctuations in either the ionizing ultraviolet background (UVB) or IGM temperature. These models make very different predictions, however, for the relationship between Ly α opacity and local density. Here, we test these models using Ly α -emitting galaxies (LAEs) to trace the density field surrounding the longest and most opaque known Ly α trough at $z < 6$. Using deep Subaru Hyper Suprime-Cam narrowband imaging, we find a highly significant deficit of $z \simeq 5.7$ LAEs within $20 h^{-1}$ Mpc of the trough. The results are consistent with a model in which the scatter in Ly α opacity near $z \sim 6$ is driven by large-scale UVB fluctuations, and disfavor a scenario in which the scatter is primarily driven by variations in IGM temperature. UVB fluctuations at this epoch present a boundary condition for reionization models, and may help shed light on the nature of the ionizing sources."

The basic conclusion is that the opaque regions of the early Universe about 12.5 billion years ago (redshift $z \sim 6$) correspond to a small number of galaxies. This is in contrast to standard model expectations. Opacity is due to the absorption of radiation by atoms and the UV radiation generated by galaxies, which ionizes atoms and makes Universe non-transparent. In standard cosmology the radiation would arrive from rather large region. The formation of galaxies is estimated to have begun .5 Gy years after Big Bang but there is evidence for galaxies already for .2 Gy after Big Bang (see <http://tinyurl.com/y9c75t2b>). Since the region studied corresponds to a temporal distance about 12.5 Gly and the age of the Universe is around 13.7 Gy, UV radiation from a region of size about 1 Gly should have reached the intergalactic regions and have caused the ionization.

Second conclusion is that there are large fluctuations in the opacity. What is suggested is that either the intensity of the UV radiation or that the density of intergalactic gas fluctuates. The fluctuations in the intensity of UV radiation could be understood if the radiation from the galaxies propagates only to finite distance in early times. Why this should be the case is difficult to understand in standard cosmology.

Could TGD provide the explanation.

1. In TGD framework galaxies would have born as cosmic strings thickened to flux tubes. This causes reduction of the string tension as energy per unit length. The liberated dark energy and matter transformed to ordinary matter and radiation. Space-time emerges as thickened magnetic flux tubes. Galaxies would correspond to knots of cosmic strings and stars to their sub-knots.
2. If the UV light emerging from the galaxies did not get far away from galaxies, the ionization of the intergalactic gas did not occur and these regions became opaque if distance to nearest galaxies was below critical value.
3. Why the UV radiation at that time would have been unable to leave some region surrounding galaxies? The notion of many-sheeted space-time suggests a solution. Simplest space-time sheets are 2-sheeted structure if one does not allow space-time to have boundaries. The members of the pair with boundary are glued to together along their common boundary. The radiation would have left this surface only partially. Partial reflection should occur as the radiation along first member of pair is reflected as a reflected signal propagating along second member. This model could explain the large fluctuations in the opacity as fluctuations in the density of galaxies.
4. A more concrete confinement mechanism would be based on the propagation of light from galaxy along magnetic monopole flux loops. If the loop is closed, it can confine the radiation. This confinement could occur also at the level of stars. The model for the solar cycle and observed anomalously high emission of gamma rays from Sun in 1-100 GeV range involves confinement of charged particles to dipole loops represented as space-time surfaces. The confinement is possible also for gamma rays.
5. Cosmic expansion occurring in TGD framework in jerk-wise manner as rapid phase transitions would

have expanded the galactic space-time sheets and in the recent Universe this confinement of UV radiation would not occur and intergalactic space would be homogeneously ionized and transparent.

The echo phenomenon could be completely general characteristic of the many-sheeted space-time.

1. The popular article "Evidence in several Gamma Ray Bursts of events where time appears to repeat backwards" (see <http://tinyurl.com/y89j6u2y>) tells about the article "Smoke and Mirrors: Signal-to-Noise and Time-Reversed Structures in Gamma-Ray Burst Pulse Light Curve" of Hakkila et al (see <https://arxiv.org/pdf/1804.10130.pdf>). The study of gamma ray bursts (GRBs) occurring in the very early Universe with distance of few billion light years (smaller than for opacity measurements by an order of magnitude) has shown that the GRB pulses have complex structures suggesting that the radiation is reflected partially back at some distance and then back in core region. The duration of these pulses varies from 1 ms to 200 s.

Could also this phenomenon be caused by the finite size of the space-time sheets assignable to the object creating GRBs? Perhaps the simplest explanation would be in terms of confinement of gamma rays inside monopole flux loops associated with the source of the radiation such as quasar or blackhole. This predicts periodic re-appearance of pulses.

2. There is also evidence for blackhole echoes, which could represent example of a similar phenomenon. Sabine Hossenfelder (see <http://tinyurl.com/ybd9gswm>) tells about the new evidence for blackhole echoes in the fusion of blackholes for GW170817 event observed by LIGO reported by Nityesh Afshordi, Professor of astrophysics at Perimeter Institute in the article "Echoes from the Abyss: A highly spinning black hole remnant for the binary neutron star merger GW170817" (see <https://arxiv.org/abs/1803.10454>). The earlier 2.5 sigma evidence has grown into 4.2 sigma evidence. 5 sigma is regarded as a criterion for discovery.

A possible TGD based comment can be found in [16] (see <http://tinyurl.com/y9suamj1>). The confinement of gravitational radiation inside monopole flux loops associated with blackhole like object would explain the findings. This however forces to replace the standard view about blackholes having no hair with TGD based view [24] allowing magnetic fields represented in terms of monopole flux tubes.

Fermi bubbles (see <http://tinyurl.com/yaj312rp>) are observed above and below Milky Way at X-ray and gamma ray energies and have radii about 11.5 thousand light years ($\sim 10^{20}$ meters). They might be due to the leakage of dark photons from the dark flux tubes of the magnetic field assignable to what is identified as galactic blackhole with mass about $4.5 \times 10^6 M_{Sun}$ and Schwarzschild radius about 1.35×10^{10} m. Dark photons would transform to ordinary photons [13].

Could one understand the radius of Fermi bubbles in TGD framework?

1. According to the proposal of [23] Planck constant decomposes as $h_{eff}/h_0 = n_1 n_2$, where n_1 and n_2 are the number of sheets as coverings of M^4 and CP_2 . $n_2 \simeq 10^7$ is needed to produce Newton's constant G from CP_2 length R taking in TGD the role of Planck length: one would have as $G = R^2/\hbar_2 = G/n_2 \hbar$. The variation of n_2 would explain the variation of G .
2. Gravitational Compton length for a particle of mass m $\Lambda_{gr} = GM/v_0$ does not depend on m (Equivalence Principle). $v_0 \simeq 2^{-11}$ is a reasonable guess from solar system [13] and would give $\Lambda_{gr} \simeq 1.35 \times 10^{13}$ m. The scale defined as $L_{gr} = n_2 \Lambda_{gr}$ equals to $L_{gr} \sim 10^{20}$ m, which is the radius of Fermi bubbles, and might have interpretation as the size of magnetic body (MB) of the blackhole like entity [24] associated with galaxy.
3. What does comparison with Sun give? For Sun with Schwarzschild radius 3 km the same formula would give $L_{gr} = 3 \times 10^{10}$ m = 2AU, the diameter of the Earth's orbit. For Mars the distance is 1.5 AU and it has very weak magnetic field now. Could this be regarded as a reasonable identification for the size of the solar MB or of its important layer. Note also that one has $\Lambda_{gr} \simeq 6 \times 10^6$ m to be compared with the radius of Earth $R_E \simeq 6.37 \times 10^6$ m.

3 About general implications of the pairing hypothesis

If wormhole magnetic fields appear in all scales, flux tube pairs and more general $n_1 = 2m_1$ multiplets of flux tubes decomposing to m_2 pairs should be universal aspect of the dynamics of TGD Universe. In the following the implications are considered only briefly. The basic consequence is of course that Universe becomes in all scales a quantum coherent object and the locality hypothesis of classical physics would be simply wrong.

3.1 Elementary particle physics

Wormhole magnetic fields appear already in elementary particle physics. Elementary particles correspond to at least 2-sheeted flux tube structures with wormhole throats containing the boundaries of string world sheets carrying fundamental fermions. I have already earlier considered the possibility that the M^4 projections of the sheets are disjoint.

Remark: In the general case one would have $n_1 = 2m_1$. Color symmetry for quarks could have as a remnant $m_1 = 3m_3$. For leptons m_1 would not be divisible by 3. Since n_1 corresponds to discrete subgroup for $SU(3)$, m_1 could correlate with the triality of $SU(3)$ partial wave defining the color quantum numbers of the particle.

3.2 Astrophysics and cosmology

The predictions in astrophysics and cosmology are in strong conflict with the locality principle of classical physics.

1. The model for magnetic spin flips in solar cycle leads to the conclusion that solar magnetic field could have doublet structure with parts related by inversion with respect to solar surface. Could the entire MB of Sun have copy somewhere. In principle this is an experimental question. The copy would be connected to Sun by wormhole magnetic flux tubes and this suggests long range correlations.

Stars indeed very often appear as binaries (see <http://tinyurl.com/oooagma>). Could these pairs be related by approximate CP_2 symmetry inducing reflection of inversion in M^4 ? Could the planets of mirror paired stars be related by Z_2 ? Could there be correlations between the rotation planes for instance.

2. What about Earth could be invariant under inversion so that the radius of Earth could define the radius remaining invariant under inversion. This could make Earth so special as far as life is considered.

Could Earth have a double in longer length scale? The least science fictive candidate would be another planet.

Mars (see <http://tinyurl.com/mttm7h8>) has radius $.53R_E$, which is the radius that Earth would have had before the Cambrian Explosion according to TGD inspired variant of Expanding Earth model [22]. Mass is 11 per cent of the Earth's mass. There are indications for life in Mars. Venus (see <http://tinyurl.com/72rz2g2>) has characteristics surprisingly near to those of Earth except that rotation is in opposite direction than for Earth: the rotation period is -243.025 days. The distances from Sun for (Venus,Earth,Mars) triplet are (.72,1.00,1.52) AU. Could Venus and Mars form a mirror pair with respect to inversion at radius R_E .

Recently Nasa found an exoplanet christened as Gliese 581d (see <http://tinyurl.com/yxdmpnbj> and <http://tinyurl.com/y2bwco6q>) located in constellation Lyra at distance of only 20.4 light years. The planet is almost exact copy of Earth as far the prerequisites of life are considered. Semimajor axis of the orbit is .22 from that of Earth. Mass is about 6.98 times higher than Earth

mass, the radius is $2.20R_E$. The Sun of the planet could be mirror image of Earth: if this is the case, there should be correlations such as common rotation planes.

3. I have considered [18] also a model for the changes of the orientation of Earth's magnetic field involving the interaction of monopole flux tubes and ordinary magnetic field via magnetic torques, and the solar model probably generalizes almost as such. Now however the orientation of the magnetic field can vary. This could relate to the fact that the axis of rotation differs from the magnetic axis. Again inversion as an approximate symmetry is suggestive.
4. The most intriguing finding about CMB spectrum is anomaly known as "Axis of Evil" (see <http://tinyurl.com/yb6nabw4>). The anomaly appears to give for the plane of planetary system of Sun and the location of Sun a greater significance than one might expect by chance. This violates the Copernican Principle. The effect resembles selection of spin quantization axis in quantum measurement of spin performed by the measurer. A possible explanation at the level of space-time is that by $h_{eff}/h_0 = n$ hierarchy disjoint space-time sheets even in cosmic length scales are related by discrete CP_2 symmetries implying correlations.

3.3 Biology

The binary structures populating biology might correspond to pairs of monopole flux tubes. The original motivation for the proposal that they are important comes from p-adic length scale hypothesis: primes $p \simeq 2^{k+2}$ and $p \simeq 2^k$, where k and $k+2$ are twin primes, could define structures with size scale $L(k+2)$ decomposing to a pair of structures with size scale $L(k)$ [5]. The structures of twin pair would form quantum entangled structures.

1. DNA and RNA double strands are basic examples of these structures. Even single DNA and RNA molecules form mirror pairs with their conjugates and could be connected by long wormhole contacts. This would make them quantum coherent structures making possible the mysterious ability of bio-molecules to find each other in the molecular crowd. Bio-systems would be extremely organized structure rather than a soup of randomly moving molecules. Could this kind of symmetries characterize all molecules that are paired or form higher structures with $n_1 = 2m_1$?
2. Cell membranes are formed by pair of lipid layers and also these could be twin pair. Epithelial sheets consist of two cell layers. At the level of body and brain there is also a pairing of sub-structures in left and right brain. Pineal gland is a connected structure could itself be a pair. Also brain hemispheres form a pair. Even married (or even non-married!) couple could form this kind of pair and what looks like a random personal relationship could be something much deeper.
3. All multi-molecular structures in living matter at least could correspond to groups of n_1 disjoint space-time sheets, perhaps magnetic flux tubes. The value of n_1 would serve as a measure for the scale of coherence and complexity.
4. Inversion corresponds to the inversion of the polarity of the Earth's magnetic field but might happen also at the cell level. In biology involution turning cell inside-out occurs during the gastrulation phase (see <http://tinyurl.com/y4pvpxyr>) of the embryonic development and leads to a development of 2 (ectoderm, endoderm) or 3 cell layers (ectoderm, mesoderm, endoderm) giving later rise to different types of tissues. This process looks rather mysterious - at least to me. Could involution be induced by the inversion of the magnetic body of the developing embryo?
5. MB controls (also our) biological body (BB) and uses scaled variants of EEG consisting of dark photons for this purpose [17]. Our MB could correspond to the part of MB above the Earth's surface or dipole core. If Z_2 acts as inversion with respect to the surface of the dipole core then also the part of MB below the surface of the dipole core should correspond to an intentional agent.

Could these MBs be associated intra-terrestrials ITs or could they control same BBs as our usual MBs? Here one must consider the precise definition of inversion: is it with respect to the surface of Earth or of the dipole core of the Earth's B ? Taking inversion in the first sense of the definition very literally, one could argue that plants having also roots are inversion invariant with respect to the Earth surface but animals are strictly speaking not inversion invariant in either sense. Could we have separate personal mirror MBs and also BBs: analogs of Dr. Jekyll and Mr. Hyde? In fact, I have have-jokingly considered a model for crop circles, and this led to a crazy idea about IT life [6, 7]. Could this idea be not so crazy as it looks first? Accepting dark matter as $h_{eff}/h_0 = n$ phases, the high temperature in Earth interior ceases to be an objection.

6. $n_1 = 2m_1$ implies also that conscious entity can have n_1 disjoint pieces. They could be MBs controlling the same BB (multiple personality disorder) or maybe even separate BBs. Could these possibly distinct BBs locate at different sides of globe or even cosmos? What comes in mind Kieslowski's trilogy "*Three colors*". When the connection between hemispheres is destroyed, brain hemispheres controlling different body halves would live effectively separate lives, and could even fight for the control of BB. This gives some ideas as one tries to image what it is to have several BBs. It is interesting that in dreams we often have different identities than in wake-up state.

3.4 Consciousness

The existence of twin pairs might have profound implications for consciousness [21, 27].

1. I proposed for about 2 decades ago what I called magnetospheric consciousness [10, 9, 6, 7]. The MB of not only Earth but also our MB would have parts assignable to the interior and exterior of the Earth. Even the structures of brain should have a scaled up MB image at both levels. The approximate inversion symmetry brings in exciting additional aspects. Maybe this division could provide the physical correlates for the Heaven-Hell dualism of religions and "*as above-so below*" dualism of perennial world views and mysticism.
2. Interior-exterior divisions are central for consciousness and the hierarchy of conscious entities in correspondence with the hierarchy of space-time sheets inspires the question whether also our biological bodies and environment could be related by an approximate symmetry at the level of MB at least so that one could speak of MBs assignable to the interior and exterior of BB. The sensory representations would reflect this approximate symmetry. Subsystem able to remain entangled at the passive boundary of CD defines the permanent part of self. But also its complement remains unentangled and should define permanent part of self: does this mean that the world outside me is a conscious entity?
3. One of the most dramatic predictions of TGD inspired theory of consciousness based on zero energy ontology (ZEO) is re-incarnation of self in death as a time-reversed self. There is indirect support for this: for instance, mental images identified as sub-selves die and re-incarnate and the period during which they are absent would correspond to the life with opposite arrow of time.

Where could these ghostly time-reversed re-incarnations live? Or putting it more formally: what regions of space-time surface do these entities control and receive sensory input from? Could inversion with respect to Earth's surface relate the space-time regions associated with self and its time reversal. If personal MB is part of MB above the Earth's surface, its inversion would be the part of MB below it. When we die we get buried. Could this ritual reflect the sub-conscious idea that our life continues as IT lifeform?

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