Morphogenesis in TGD Universe

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Abstract

The problem of structure formation in biology - morphogenesis - was put under the rug by most biologists after the emergence of genetics. Sheldrake is one of those who have taken it seriously and has been labelled as a crackpot by mainstreamers. One just assumes that the structures are there and performs chemistry around these structures. This approach is very practical and has given an enormous amount of data but very little understanding.

In standard physics the description of spatial structures would be in terms of enhanced densities of biomolecules or of their gradients in some space-time region. This is the only possibility because the space-time of standard physics is topologically and geometrically utterly trivial. Empty Minkowski space is an excellent approximation for it.

If space-time topology were topologically non-trivial, situation would change dramatically. Already Wheeler saw this possibility and in the biology inspired by TGD all structures correspond to structures of topologically non-trivial space-time identified as surface in certain 8-D space-time: space-time sheets, magnetic flux tubes, etc... The entire TGD inspired quantum biology relies on this vision. The structures that we see around us would represent the non-trivial topology of space-time surface.

All structures - including bio-molecules, membrane like structures, organelles, organs, ... - would be 4-D space-time surfaces. This would reduce the notion of shape in biology to a precisely defined and testable geometrodynamics coupling to em fields.

Contents

1 Introduction

The problem of structure formation in biology - morphogenesis - was put under the rug by most biologists after the emergence of genetics. Sheldrake [L1, I5] is one of those who have taken it seriously and has been labelled as a crackpot by mainstreamers (I have discussed Sheldrake's views from TGD point of view in [L1, L4]). One just assumes that the structures are there and performs chemistry around these structures. This approach is very practical and has given an enormous amount of data but very little understanding.

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What philosopher has to say about this? If space-time topology were topologically non-trivial, situation would change dramatically. Already Wheeler saw this possibility and in the biology inspired by TGD (for which Wheeler suggested its name) all structures correspond to structures of topologically non-trivial space-time identified as surface in certain 8-D space-time: space-time sheets, magnetic flux tubes, etc... The entire TGD inspired quantum biology relies on this vision. The structures that we see around us would represent the non-trivial topology of space-time surface.

All structures - including bio-molecules, membrane like structures, organelles, organs, ... - would be 4-D space-time surfaces. Again philosopher gets excited since this would reduce the notion of shape in biology to a precisely defined and testable geometrodynamics coupling to em fields.

In the following I discuss a vision about morphogenesis as being due to the coupling between gravitation and what I call induced Kähler field to which em field is closely related, is studied in more detail. This picture follows from the twistor lift of Kähler action reducing to a sum of Kähler action and volume term having interpretation in terms of cosmological constant depending on p-adic length scale. Coupling means energy transfer between these two kinds of degrees of freedom, and field equations allow two kinds of preferred extremals. The first kind of extremals are minimal surfaces and there coupling is absent. One cannot have closed stationary surfaces as minimals surfaces. Second kind of extremals have this coupling making possible closed surfaces as extremals essential for the understanding of living matter. The twistor lift of TGD allows to gain quantitative grasp about the model by simple order of magnitude estimates and a surprising connection between astrophysical and biological scales emerges. This connection is understandable if quantum coherence is possible in all scales.

2 General view about morphogenesis

This dynamics predicts two kinds of space-time regions [L3] (see `http://tinyurl.com/yboog5sr`.

1. The regions of first kind are locally minimal surfaces. These minimal surfaces are as 4-D analogs of geodesic lines analogs of asymptotic states of particle physics for which interactions are not on. They also satisfy non-linear geometrization of massless field equations so that both particle and wave aspects are present. What is especially important is that static minimal surfaces have vanishing mean curvature and look like saddles locally. They cannot be closed surface if stationary.

2. Second type of regions are not minimal surfaces: there is a non-trivial coupling of the minimal surface term to 4-force density analogous to the divergence of Maxwellian energy momentum tensor. This is a generalization of the dynamics of a point-like charged particle in Maxwell field. These regions are identified as interaction regions: in particle physics these two regions correspond to external free particles and the interaction region. Magnetic flux tubes play fundamental role in TGD based quantum biology are deformations of string like objects, which represent simplest 4-D minimal surfaces.

   Essential is the coupling between induced Kähler form (mathematically like Maxwell field) and the geometry of the surface: the divergence of energy momentum current assignable to the analog of cosmological term (4-volume) equals to the divergence of that assignable to Kähler action: this expresses local conservation of four-momentum. One could also speak about coupling between Kähler field and gravitational field: Penrose's intuition about the the role of gravitation in biology would be correct.

   When the coupling is absent, minimal surface property implies the separate vanishing of both divergences and separate conservation of corresponding energy-momenta. All the known extremals of Kähler action are minimal surfaces: this is due to their very simple algebraic properties making easy to discover them. Physically this correspond to quantum criticality: dynamics is universal and does not depend on coupling parameters.

These observations lead to a rather general view about morphogenesis.

1. The presence of the Kähler field (em field is sum of Kähler field and second term) makes possible flow equilibria such as cell membrane, which are not minimal surfaces. These surfaces

can be closed and stationary making possible isolation from environment crucial for living organisms.

Spherical soap bubble is a good analogy: it is not minimal surface as the soap films spanned by frames are. They look locally like saddle surfaces with opposite external curvatures in two orthogonal directions, this implies that they cannot be closed surfaces. Bubble is not possible without a pressure difference Δp between the interior and exterior of the bubble: the blowing of the soap bubble generates Δp, and means external energy feed analogous to metabolic energy feed.

Δp is analogous to a non-vanishing voltage V over cell membrane. The electric field of cell membrane and the energy feed providing the energy of electric field as metabolic energy are essential for the stability. More generally, V would generalize to non-vanishing of energy momentum tensor of Kähler field with non-vanishing divergence serving as a correlate for the energy transfer between Kähler and volume (gravitational) degrees of freedom.

This generalises to all morphologies, which correspond to closed surfaces. They necessarily involve both Kähler electric and magnetic fields coupling to the geometry to stabilize the morphology. This statement would give some content for the exaggerated claim that biology is nothing but electricity + Schrödinger equation that I heard during my first student year.

2. For instance, the presence of Kähler electric field can correspond to electric fields of cell membrane or along a part of body. If it is too weak, things go wrong in development. As was found decades ago, consciousness is lost if the electric field between frontal lobes and hindbrain gets too weak or has wrong direction [J1]. Cell dies if the membrane potential becomes zero and EEG disappears in death. Also microtubules have electric field along their axes essential for their existence.

   Michael Levin and his collaborators [I2, I3, I6] have discovered further fascinating connections between electric fields and morphogenesis. One of the discoveries is that the electric fields of the embryo are controlled by neurons of the still developing brain (see `http://tinyurl.com/y77fcc7r`). This conforms with the view that neurons and their MBs correspond to a higher level in the hierarchy than ordinary cells and there take care of control in longer scales. The MB of the developing brain would be the controller.

3. A non-trivial coupling (four-momentum transfer) between the volume and Kähler degrees of freedom requires that the energy momentum currents have opposite and non-vanishing divergences. For the energy momentum tensor of ordinary Maxwell field the divergence is proportional to the contraction of Maxwell current and Maxwell field so that the current must be non-non-vanishing.

   In TGD the energy momentum tensor is replaced with energy momentum current allowing to have well-defined notion of energy momentum and corresponding conservation laws. Now the divergence contains two terms. The first one is the contraction $Tr(T_K H^k)$ of energy momentum tensor T_K of Kähler action with the second fundamental form H^k: this term proportional to T_K is new. Second term is proportional to the contraction $j_K J \nabla h^k$ of the induced Kähler form J with Kähler current j_K and gradients ∇h^k of imbedding space coordinates analogous the divergence of energy-momentum tensor $j^\beta F^\alpha_{\ \beta}$ in the case of ordinary Maxwell action. One expects both terms to be non-vanishing.

   For the mere Kähler action, which I believed for decades to determine the preferred extremals, j_K is either vanishing or light-like. In presence of coupling it can be both non-vanishing and time-like. The realization that cosmological term is present was forced by the twistor lift of TGD whose existence is possible only for $H = M^4 \times CP_2$ [K2, K8].

4. The predicted stabilizing Kähler (and em) currents would naturally correspond to the DC currents flowing along the body in various scales discovered already by Becker [J3, J2, J1] and found to be essential for the survival of the organism. In particular, Becker's DC currents are essential for the healing of wounds and in the regeneration of organs. In the first first aid stage of the healing DC currents are generated locally and after than central nervous system (CNS) takes care of the generation of the current (for TGD based discussion of

Becker currents see [K4] (see `http://tinyurl.com/ydg6okkk`) or [K1]). Also this is easy to understand from the proposed stability criterion.

3 Quantitative view

The emergence of life would require the coupling between Kähler and volume degrees of freedom. The following gives a quantitative discussion based on p-adic length scale hypothesis and twistor lift of TGD [K2, K7].

1. The coefficient $\Lambda/8\pi G \equiv 1/L^4$ of the volume term in the action is analogous to cosmological constant in general relativity. The predicted wrong sign of Λ is the stumbling block of superstring theories. In TGD framework the sign is correct.

2. p-Adic coupling constant evolution predicts that the cosmological constant depends on p-adic length scale $L(k)$ characterizing the size scale of the Universe, most naturally as that of horizon size. In zero energy ontology (ZEO) $L(k)$ is identifiable as the size scale of causal diamond (CD) [K7].

   One important implication is a solution to the problem of cosmological constant. Although cosmological constant is huge at very early times (or more precisely, in very short p-adic length scales), it is small in the length scales of recent cosmology. The values of cosmological constant at smaller p-adic lengths scales are however visible also in the recent day physics in many-sheeted space-time and biology could make them visible as the following arguments show.

3. There are two paired p-adic length scales: short p-adic length scale $L(k_1)$ and long p-adic length scale $L(k)$. The vacuum energy density $\rho_{vac} = \Lambda/8\pi G$ is naturally proportional to $1/L^4(k_1)$. One has energy $E = 1/L(k_1)$ per 3-volume $L(k_1)^3$.

   $\rho_{vac} = \Lambda/8\pi G$ is also naturally proportional to $1/GL^2(k)$ since $\Lambda = x/L(k)^2$ is natural by dimensional considerations. If $L(k)$ corresponds to the size scale of the horizon, Λ degreases during cosmic evolution and the problem of cosmological constant disappears. One has

$$\frac{1}{L^4(k_1)} = \frac{\Lambda}{8\pi G} \quad , \quad \frac{\Lambda}{8\pi} = \frac{x^2}{L^2(k)} \quad . \tag{3.1}$$

   Here the p-adic length scale $L(k)$ could characterize the p-adic size scale of CD. $G = l_{Pl}^2$ is gravitational constant, l_{Pl} Planck length scale, and $L = L(k_1)$ is a smaller length scale. $L(k_1)$ expressible using the geometric mean

$$L(k_1) = (\frac{8\pi G}{\Lambda})^{1/4} = x^{-1/2}\sqrt{L(k)l_{Pl}} \quad . \tag{3.2}$$

   of $L(k)$ and Planck length l_{Pl} and allows an identification as a p-adic length scale for a suitable choices of the parameter x [K7]. One has $(8\pi)^{1/4} \simeq 2.4$.

   What could this pairing of short and long p-adic length scales mean? The notion of magnetic body (MB) could provide and explanation. MB has onion-like layered structure with layers labelled by p-adic length scales up to some maximum size scale. This suggests that a biological structure with size scale $L(k_1)$ has MB for which the largest layer has the size scale $L(k)$. $L(k_1)$ would correspond to smallest length scale in the hierarchy. Both scales could correspond to size scales of CDs.

   Remark: When $L(k_1)$ is scaled by 2^r $(k_1 \to k_1 + r)$, $L(k)$ is scaled by 2^{2r}, $(k \to k + 2r)$.

4. From the parameterization

$$\rho_{vac} = y\frac{H^2}{8\pi G} \tag{3.3}$$

of the dark energy density in terms of Hubble constant at given space-time sheets one obtains an estimate for the inverse of the Hubble constant H, which depends on space-time sheet in terms of $L(k)$, as

$$\frac{1}{H(k)} = \sqrt{\frac{y}{8\pi x}} L(k) \quad . \tag{3.4}$$

$H(k)$ refers now to Hubble constant in given p-adic length scale characterizing a level in the hierarchy of space-time sheets and is *not* the ordinary Hubble constant defined in very long scales at GRT limit of TGD. Naturality suggests the condition $\sqrt{\frac{y}{8\pi x}} = 1$.

One expects that the coupling between Kähler action and volume term can be non-vanishing only if the two contributions to the energy momentum tensor are of the same order of magnitude. Otherwise minimal surface property takes care that field equations are satisfied, and one does not obtain closed membrane like structures crucial for life.

1. To achieve this, Kähler action $\propto E^2 - B^2$ must be of the same order of magnitude as $(\Lambda/8\pi G) \equiv x/GL^2(k)$ giving in the case of cell membrane for the Kähler electric field strength the rough estimate

$$E \sim \frac{\sqrt{x}}{l_{Pl} L(k)} \quad . \tag{3.5}$$

Remark: The electric field of the cell membrane corresponds to $E \sim 5 \times 10^{-4}$ eV^2 in the units of particle physicist ($\hbar = 1$ and $c = 1$) in which unit of distance is $1/eV$ and one has $1\ m \leftrightarrow 1.24 \times 10^6$ eV^{-1}.

2. If an estimate for the typical strength E of bio-electric field is given, one can get some idea about the length scale $L(k)$ as

$$L(k) = \frac{\sqrt{x}}{l_{Pl} E} \quad . \tag{3.6}$$

By feeding in Planck length $l_{Pl} \sim 1.6 \times 10^{-35}$ m and the electric field $E \sim 5 \times 10^6 V/m$ of the cell membrane, one obtains for the cell membrane the estimate

$$\begin{array}{l} L(k) \sim \sqrt{x} \times L_0 \quad , \quad L_0 = 1.1 \times 10^6 \ \text{ly} \quad . \\ L(k_1) = x^{-1/4} L_1 \quad , \quad L_1 = \sqrt{l_{Pl} L_0} = 4.2 \times 10^{-7} \ \text{m} \quad . \end{array} \tag{3.7}$$

Note that $L(k)$ scales as $x^{1/2}$ and $L(k_1)$ as $x^{-1/4}$.

3. The value of electric field for cell membrane is essential for the argument. If one wants to generalize the argument from cell membrane to other systems, one must have an idea about how it scales. Membrane potential is near the value for which the potential energy ZeV_0 for a Cooper pair is slightly above the thermal energy at physiological temperature. Hence the possible magnetic flux tube assignable to membrane proteins acting as Josephson junctions through cell membrane carry weakest possible electric field: this conforms with metabolic economy. A natural generalization would be that for a flux tube of length L one has $E = V_0/L$. This gives the scalings

$$L(k) \propto (\tfrac{L}{L_c}) \quad , \quad L(k_1) \propto (\tfrac{L}{L_c})^{1/2} \quad . \tag{3.8}$$

The value of the parameter x is open and one can make only guesses. Naturality would suggest that x is not too far from unity.

Option I: The size of the Milky Way is estimated to be about $L_{MW} = 10^5$ ly. $L(k) = L_{MW}$ would be obtained for $x = .01$. One should be however cautious with this estimate: also $x \sim 1$ might be acceptable.

1. For $L(k_1)$ the formula $L(k_1) = x^{-1/2}\sqrt{L(k)l_{Pl}}$ gives for $x = .01$

$$L(k_1) = 4 \text{ nm} \ .$$

   This is near the p-adic length scale $L(149) = 5$ nm assignable to the ordinary cell membrane. There are indeed indications that galactic year defines a biorhythm [K5]. For $x = 1$ giving $L(k) = 10^6$ ly one would have $L(k_1) = 1.26$ nm, which does not correspond to cell membrane length scale.

2. For the inverse of the Hubble constant $H(149)$ one obtains for $x = .01$ the estimate

$$\frac{1}{H(k)} \simeq 2\sqrt{\frac{y}{8\pi x}}L(k) \ . \tag{3.9}$$

   $H(149)$ does not correspond to standard cosmological constant. One has $H(149) = L(k)$ for $y = 2\pi x = .0628$.

3. The scaling $L(k) \to 10^5 L(k)$ the size scale of the observed Universe about 15 Gly scales $L(k_1 = 149)$ to $L(k_1) = 1.3$ μm, which corresponds to $L(165) = 1.25$ μm in a reasonable approximation ($L(167) = 2.5$ μm is the p-adic length scale of nuclear membrane). This scale would correspond to a distance through which one has membrane potential V_0. Could the size scales of galaxy and observed Universe indeed correspond to those of lipid layer of cell membrane and cell membrane?

Option II: One could argue that the long length scales correspond to the size scale of Earth. In TGD based view about EEG MB as onion-like structure has also layer with size scale of Earth radius R_E.

1. The condition that $L(k) = R_E = 6.3 \times 10^6$ m gives $x = 6.4 \times 10^{-16}$ and $L(k_1) = 6.7$ mm. $L(k_1)$ could characterize a brain structure involved in the generation of EEG. Note that the estimate assumes the electric field of cell membrane. One can argue that the value of $x = 6.4 \times 10^{-16}$ is highly un-natural.

2. There are indications for the existence of life in Mars, whose radius is 1/2 of that for Earth. $L(k)$ would scale down by 1/2 as also the cell membrane thickness. Could this be assumed also for the **Option I**? By the proposed criterion the strength of electric field E for cell membrane should be 2 times stronger than for Earthly cell (for same physiological temperature). For instance, membrane potential could be same but membrane thickness could be 1/2 of that for Earthly membrane.

   Interestingly, the TGD based version of Expanding Earth model [L14, L13] predicts that Earth experienced a rapid expansion doubling its radius. Even more, neuronal cell membranes are 2 times thicker than ordinary cell membranes. Animals utilizing aerobic respiration emerged in Cambrian explosion and eventually also neurons and TGD suggests an explanation in terms of oxygenation as the life in underground oceans entered to the surface through the cracks generated by the expansion [L15].

4 Morphogenesis in astrophysical scales?

The proposed general picture has interesting implications for the TGD view about stars and planets. Minimal surfaces have vanishing mean curvature vector H^k defined by the trace of the

second fundamental form. The external curvatures sum up to zero and the surface looks like saddle surface locally. This strongly suggests that one cannot have (spherically symmetric) closed 3-surfaces obtained by taking two almost copies of 3-surface having a boundary and gluing them together along boundaries as the assumption that there are not boundaries requires. Could stars and planets be flow equilibria analogous to soap bubbles for which pressure difference is necessary and is provided by an external energy feed (blowing the bubble). When the energy feed ceases, the bubble collapses? The analogy with the stellar dynamics leading eventually to a collapse to a blackhole is obvious.

4.1 Morphogenesis and metabolic energy feed in astrophysical scales as explanations for puzzling findings?

The analogy with morphogenesis could allow to build a more coherent picture from several puzzling observations related to TGD made during years.

1. One cannot obtain an imbedding of Schwartschild exterior metric without the presence of long range induced gauge field behaving like $1/r^2$ [K3]. Any object with long range gravitational field must have also electroweak gauge charge. The charge can be made arbitrarily small but must be non-vanishing. The natural guess was that em charge - closely related to Kähler charge - is in question. If flow equilibrium analogous to soap bubble is in question, the charge must be Kähler charge with the energy momentum currents of Kähler field feeding energy to prevent gravitational collapse.

2. During 1990s I did considerable amount of work [K3] in attempts to construct spherically symmetric solutions of field equations using only Kähler action but failed. In this case, the field equations state the vanishing of the divergences of energy-momentum and color currents. All known extremals of both Kähler action and its twistor lift involving also volume term analogous to cosmological term are minimal surfaces and extremals of both Kähler action and volume term.

   The failure to discover extremals which are not minimal surface might be simply due to the fact that they are not simple. One can however ask whether there are actually no radially symmetric stationary extremals of Kähler action? Could volume term be needed to stabilize them?

3. 4-surfaces with vanishing induced Kähler field are necessarily minimal surfaces. The vanishing of induced Kähler field is however not necessary. In fact all non-vacuum extremals of Kähler action are minimal surfaces. The known repertoire of minimal surfaces includes cosmic strings, massless extremals representing radiation, and CP_2 type extremals with Euclidian signature of induced metric representing elementary particles. For these Kähler action is present but minimal surface field equations give extremal property separately in volume and Kähler degrees of freedom.

   Cosmic strings would dominate in the very early cosmology before space-time as a 4-surface with 4-D M^4 projection had emerged. The vision is that the thickening of their M^4 projection during cosmic expansion generated Kähler magnetic flux tubes carrying magnetic monopole fluxes. The thickening of cosmic strings need not leave them minimal surfaces but one expects that this is true approximately.

   The feed of energy and particles from flux tubes (suggesting that they are not minimal surfaces) would have generated visible matter and led to the formation of stars. The flux tubes would take the role of inflaton field in standard approach. Flux tubes would have also second role: they would carry the quanta of gravitational and gauge fields and thus would be mediators of various interactions.

   Dark matter identified as phases with non-standard value of Planck constant $h_{eff}/h_0 = n$ having purely number theoretical origin in adelic physics [L8, L9] would reside at magnetic flux tubes and the general vision about TGD inspired biology is that it controls the ordinary biomatter, which would involve metabolic energy feed as a stabilizer of the flow equilibrium. This picture suggests a generalization.

4. The vision about dark nucleosynthesis [L7], which emerged from the model of "cold fusion" has led to the proposal that dark nucleosynthesis preceded ordinary nucleosynthesis. Dark proton sequences were generated first by the analog of Pollack effect [L2], [L2] at magnetic flux tubes suffering also weak decays to produce states involving dark neutrons. These states decayed to dark nuclei with smaller value of $h_{eff}/h = n$ and eventually this process led to the formation of ordinary nuclei. This process liberated practically all nuclear energy and heated the system and led eventually to the ordinary nuclear fusion occurring in the cores of stars.

   In living systems dark nuclei realized as dark proton sequences realize dark analogs of DNA, RNA, amino-acids, and tRNA and would provide the fundamental realization of the genetic code [L11, L10]. This picture predicts a hierarchy of dark nuclear physics and dark realizations of the genetic code and analogs of the basic biomolecules. Could biology be replaced by a hierarchy of "biologies" in a more general sense.

5. In the generalized biology stellar cores would provide metabolic energy realized basically as energy flow associated with Kähler field in stellar core making possible to realize star as an analog of cell membrane as flow equilibrium. Also the flow of Kähler charge, presumably in radial direction, would be involved if the energy momentum current of the induced Kähler field is non-vanishing and could relate to the mass loss of stars.

   Even in the case of planets dark nucleosynthesis could provide a radial energy flow to guarantee stability. Nucleosynthesis could have occurred inside planets and have produced heavier nuclei. The standard picture about stars as providers of heavier elements and supernova explosions giving rise to fusion generating elements heavier than Fe could be wrong.

6. This picture conforms with what we know about dark matter. Dark matter would consist of $h_{eff}/h_0 = n$ phases of ordinary mater at magnetic flux tubes. If also magnetic flux tubes are minimal surfaces in good approximation, gravitational degrees of freedom assignable to the volume action as analog of Einstein-Hilbert action and stringy action would not interact with Kähler degrees of freedom appreciably except in the events in which dark energy and matter are transformed to ordinary matter. These events could be induced by collisions of magnetic flux tubes. The energy exchange would be present only in systems not representable as minimal surfaces. Dark matter in TGD sense has key role in TGD inspired quantum biology.

Solar corona could be also a seat of dark nucleosynthesis and there are indications that this is the case (see `http://tinyurl.com/y7g9sjfl`) . The metallicity of stellar objects gives important information about its size, age, temperature, brightness, etc... The problem is that measurements give two widely different values for the metallicity of Sun depending on how one measures it. One obtains 1.3 per cent from the absorption lines of the radiation from Sun and 1.8 from solar seismic data. Solar neutrinos give also the latter value. What could cause the discrepancy?

Problems do not in general appear alone. There is also a second old problem: what is the origin of the heating of the solar corona. Where does the energy needed for the heating come from?

TGD proposal is based on a model, which emerged initially as a model for "cold fusion" (not really) in terms of dark nucleosynthesis, which produced dark scaled up variants of ordinary nuclei as dark proton sequences with much smaller binding energy [L7]. This can happen even in living matter: Pollack effect [L2] involving irradiation by IR light of water bounded by gel phase creates negatively charged regions from which part of protons go somewhere. They could go to magnetic flux tubes and form dark nuclei [L2]. This could explain the reported transmutations in living matter not taken seriously by academic nuclear physicists [K6].

TGD proposal is that the protons transform to dark proton sequences at magnetic flux tubes with nonstandard value of Planck constant $h_{eff}/h_0 = n$. Dark nuclei with scaled up size. Dark nuclei can transform to ordinary nuclei by $h_{eff} \to h$ ($h = 6h_0$ is the most plausible option [L5, L12] and liberate almost all nuclear binding energy in the process. The outcome would be "cold fusion".

This leads to a vision about pre-stellar evolution [L7]. First came the dark nucleosynthesis, which heated the system and eventually led to a temperature at which the ordinary nuclear fusion started. This process could occur also outside stellar cores - say in planet interiors - and a considerable part of nuclei could be created outside star.

A good candidate for the site of dark nucleosynthesis would be solar corona [L7]. Dark nucleosynthesis could heat the corona and create metals also here. They would absorb the radiation coming from the solar core and reduce the measured effective metallicity to 1.3 per cent.

4.2 Blackhole collapse as an analog of biological death?

Before one can say something interesting about blackholes in this framework and must look more precisely what cosmic strings are. There are two kinds of cosmic strings identifiable as preferred extremals of form $X^2 \times Y^2 \subset M^4 \times CP_2$. X^2 is minimal surface.

1. Y^2 can be homologically non-trivial complex sub-manifold of CP_2 for which second fundamental form vanishes identically. Induced Kähler form is non-vanishing and defines monopole flux. Both Kähler and volume term (cosmological constant term formally at least) contribute to energy density but the energy momentum currents and also tensors have vanishing divergence so that there is no energy flux between gravitational and Kähler degrees of freedom.

2. Y^2 can be also homologically trivial geodesic sphere for which Kähler form and therefore Kähler energy density vanishes identically. In this case only cosmological constant Λ represents a non-vanishing contribution to the energy so that energy transfer between gravitational and Kähler degrees of freedom is trivially impossible.

What could happen in blackhole collapse?

1. Blackhole is not able to produce "metabolic energy" anymore and preserve the spherically symmetric configuration anymore. The outcome of blackhole collapse could be a highly folded flux tube very near to minimal surface or perhaps, or even a cosmic string. The latter option is not however necessary.

2. Is this string homologically non-trivial having large string tension or homologically trivial and almost vacuum for small values of Λ? The huge mass density of blackhole does not favour the latter option. This leaves under consideration only the homologically non-trivial cosmic strings or their deformations to flux tubes.

   The string tension for cosmic string is estimated to be a fraction of order 10^{-7} about the effective string tension of order $1/G$ determined by blackhole mass which is proportional to the Scwartschild radius. Therefore the cosmic string should be spaghetti like structure inside the horizon having length about 10^7 time the radius of blackhole. Note that TGD predicts also second horizon below Schwartschild horizon: the signature of the induced metric becomes Euclidian at this horizon and this could explain the echoes claimed to be associated with the observed blackhole formation [L6, L16].

3. One could say that Big bang starting from homologically non-trivial cosmic strings would end with Big crunch ending with similar objects.

Living systems are conscious and there is indeed a strong analogy to TGD inspired theory of consciousness. One could say that the particular sub-cosmology corresponds to a conscious entity (many-sheeted space-time predicts a Russian doll hierarchy of them) which repeatedly lives and dies and re-incarnates with opposite arrow of time.

1. In zero energy ontology (ZEO) key role is played by causal diamonds (CDs) carrying analogs of initial and final states at their boundaries are in key role. The M^4 projection of CD is intersection of future and past directed light-cones. The shape of CD strongly suggests Big Bang followed by Big Crunch.

2. TGD inspired theory of consciousness predicts that conscious entities - selves - correspond to a generalized Zeno effect. Self is identified as a sequence of "small" state function reductions (weak measurements) increasing gradually the size of CD by shifting the active boundary of CD farther away from that passive boundary which is not changed (Zeno effect).

   The states at the active boundary are affected unlike those at the passive boundary. Self dies when the first "big" state function reduction to the active boundary occurs and the roles of

the active and passive boundary are changed. The arrow of geometric time identified as the distance between the tips of CD changes and the CD starts to grow in opposite time direction. The evolution of self is a sequence of births and deaths followed by a re-incarnation.

3. In astrophysical context this evolution would be a sequence of lifes beginning with a Big Bang and ending with a Big Crunch with two subsequent evolutions taking in opposite time directions. Somewhat like breathing. This breathing would take place in all scales and gradually lead to a development of sub-Universes as the size of CD increases.

4. In ZEO the first big state function reduction to active boundary of CD occurs when all weak measurements have been done and there are no observables commuting with the observables, whose eigenstates the states at the passive boundary are. Self dies and reincarnates.

   One can also try to build a classical view about what happens. Measurement involves always a measurement interaction generating entanglement. Could the transfer of quantum numbers and conserved quantities (also color charges besides Poincare charges) between Kähler and volume degrees of freedom define the measurement interactions in practice. When this transfer vanishes, there is no measurement interaction and no further measurements are possible. Also metabolism ceases and self dies in biological sense.

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