New support for the view about Cambrian explosion being caused by rapid increase of Earth radius

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Abstract

Cambrian explosion during which highly advanced lifeforms suddenly emerged is one of the mysteries of biology. Oxygenation of the environment was associated with this event as also a release of methane trapped to a crystal structure of water. Oxygenation made possible the emergence of aerobic respiration and of animals. Stem cells to not however tolerate oxygen. The so called hypoxia-inducible factors (HIFs) make possible to shift metabolism from aerobic to anaerobic in hypoxic environment. In the case of cancer cells so called HIF-2α allows this also in oxic environment. The geobiologis Emma Hammarlund and tumor biologist Sven Påhlman conjecture that this true also for the ordinary cells. Moreover, they propose that the event induced a genetic change leading to the emergence of what they call HIF-1 as a predecessor of HIF-2α. This allowed the organism to adapt to environments in which oxygen concentration varied so that stem cells survived in high-oxygen environment.

The cause of the sudden oxygenation is not discussed in the article. The so called Great Oxygenation Event (GOE) occurred much earlier than Cambrian explosion, and TGD inspired proposal is that this event drove the primitive life forms under the Earth surface to underground oceans. The pre-Cambrian situation would have been very similar to that in recent Mars. Cambrian explosion was induced by a rapid expansion of Earth size with radius increasing by a factor of 2. This led to the formation of cracks and oxygenation of underground oceans which in turn induced rapid evolution of animals from plant like predecessors.

The findings towards end of 2019 suggests that Mars has much stronger magnetic field at surface than expected and that there is intramartial ocean. These findings are discussed from TGD view point.

Contents

1 Introduction

There was an interesting popular article in Quanta Magazine titled "*Oxygen and Stem Cells May Have Reshaped Early Complex Animals*" (see http://tinyurl.com/y86ta45l).

The article dicusses the work of geobiologist Emma Hammarlund and tumor biologist Sven Påhlman: their interdisciplinary hypothesis is published as article in Nature [I2] with title "*Refined*

control of cell stemness allowed animal evolution in the oxic realm" (see `http://tinyurl.com/y85ufngz`).

Here is the abstract of their article.

Animal diversification on Earth has long been presumed to be associated with the increasing extent of oxic niches. Here, we challenge that view. We start with the fact that hypoxia ($\leq 1-3$ per cent O_2) maintains cellular immaturity (stemness), whereas adult stem cells continuously - and paradoxically- regenerate animal tissue in oxygenated settings. Novel insights from tumour biology illuminate how cell stemness nevertheless can be achieved through the action of oxygen-sensing transcription factors in oxygenated, regenerating tissue. We suggest that these hypoxia-inducible transcription factors provided animals with unprecedented control over cell stemness that allowed them to cope with fluctuating oxygen concentrations. Thus, a refinement of the cellular hypoxia-response machinery enabled cell stemness at oxic conditions and, then, animals to evolve into the oxic realm. This view on the onset of animal diversification is consistent with geological evidence and provides a new perspective on the challenges and evolution of multicellular life.

1.1 The proposal of Hammarlund and Påhlman

Cambrian explosion (see `http://tinyurl.com/ntvx38e`) during which highly advanced lifeforms suddenly emerged - prolifiration and diversification of animal life are the terms used about this - is one of the mysteries of biology. For most of its 4.5-billion-year history, Earth has sustained life but that life was largely limited to microbial organisms: bacteria, plankton, algae. For about 540 million years ago did larger, more complex species are assumed to dominate the oceans, but within just a few tens of millions of years (very short time on the evolutionary timescale), the planet had filled up with all kinds of animals. The fossil record from that period shows the beginnings of almost all modern animal lineages: animals with shells and animals with spines, animals that swam and animals that burrowed, animals that could hunt and animals that could defend themselves from predators. Also many lineages that disappeared were present as one learns from the book of Stephen Jay Gould describing in detail the Burgess Shale finding that revolutionized the picture about evolutionary biology and remains still a puzzle (see `http://tinyurl.com/y9orfy43`).

The belief is that the environment became considerable more oxic - that is contained oxygen - and lifeforms had to cope with this change. Before the change the animals in seas (believed to exist!) were anaerobic. The shifting to aerobic respiration was however an enormous metabolic advantage since the effectiveness of metabolic energy gain become roughly 20-fold. Increased metabolic feed in turn made possible the emergence of complexity during Cambrian period.

1. The proposal of the authors is that the evolution of the capacity to maintain stem cells even in an oxic environment allowed the animals to keep stocks of stem cells needed for tissue growth and repair for that this required at gene level new genes coding for so called HIFs.

2. Stem cells require low oxygen levels to preserve their stemness. Heightened oxygen levels cause them to differentiate abruptly. This explains why stems cells are often located in hypoxic regions of the body (say bone marrow) having low oxygen levels. There are however exceptions to this rule: stem cells can also survive in ocix regions such as skin or retina. Cancers also utilize stem cells to achieve growth.

3. Hammarlund and Påhlman turned their attention to HIFs (hypoxia-inducible transcription factors), which are proteins, which for hypoxic environment shift the metabolism from aerobic to an-aerobic. For oxic environment they are not needed.

   HIF-2α remains however active also in oxic environment and make the cells behave as if the environment were hypoxic. This would allow the stem cells to survive. HIF-2α would however keep the stem cells in immature state also in the case of cancer. The hypothesis of Hammarlund and Påhlman was that HIF-2α functions similarly in normal animal tissues. They have seen some preliminary evidence for the hypothesis but further work is needed.

4. HIFs could have helped the animals to survive in oxic environment. Consider an organism as a blob of cells. Before the oxygenation the stem cells would have been forced to the deep interior of the blob, where oxygen concentration was especially low. When oxygenation took place, and oxygen level varied, this trick did not work anymore and HIFs had to be invented.

5. Hammarlund and Påhman postulate what they call HIF-1, which would have helped stem cells to behave as if the environment were hypoxic. Later HIF-2α unique to vertebrates emerged and improved the situation further. Vertebrates are bigger and have longer time spans that invertebrates and they can live in oxygenated environments. Inveratebrates such as insects live most of their life as larvae under low-oxygen conditions and they cannot regenerate tissues as vertebrates can.

6. Cancer would be the price paid for this evolutionary advance since cancer cells can proliferate because HIF-2 keeps the stem cells alive. OH present in oxygen rich environment is an oxidant causing cancer.

What caused the oxygenation? So called Great Oxygenation Event (GOE,see `http://tinyurl.com/q7qfd55`) is believed to have occurred about about 2.25 billion years ago and thus preceded Cambrian explosion that occured about .5 billion years ago.The time lapse between these events is about 1.75 billion years and much longer than the duration of Cambrian period, which was only tens of millions years. Thus GOE was not the reason for the Cambrian explosion. What caused a further oxygenation or were the effects of GOE somehow postponed (wink-wink!)?

2 TGD view

My own proposal is that life evolved in underground oceans and entered to the surface of Earth in Cambrian explosion (see `http://tinyurl.com/ntvx38e`) when oceans were formed at the surface of Eearth from cracks formed when Earth expanded rapidly in geological time scale. Before the explosion Earth did not have oceans and continents and was like Mars nowadays: even its radius was that of Mars. This picture follows from TGD based variant of Expanding Earth hypothesis [L10, L9] (see `http://tinyurl.com/yc4rgkco` and `http://tinyurl.com/yb68uo3y`) .

The habitat changed in the rapid expansion of Earth from hypoxic to oxic and the emergence of the hypothetical HIF-1 transcription factor would have been forced by this evolutionary pressure and made it possible for the lifeforms to adapt oxygen based metabolism. This would have led to a rapid evolution of animals and emergence of vertebrates. One can of course think that oxygenation developed already in the underground oceans as cracks caused in the crust by the expansion of Earth began to develop and provided oxygen. The alternative - not so plausible sounding - option is that the highly developed organisms developed underground slowly and only bursted to the surface of Earth in the explosion.

1. Chemical markers (see `http://tinyurl.com/ntvx38e`) indeed indicate dramatic change in the environment at the start of the Cambrian period. The markers are consistent with a massive warming due to the release of methane ice (clathrate hydrate, see `http://tinyurl.com/peq9gmw`) trapped within the crystal structure of water. Methane clathrate is found deep under the sediments at the ocean floors. Methane hydrates are believed to form by migration of gas from deep along geological faults (the cracks produced by rapid expansion of Earth [L9]!).

2. During the period before Cambrian explosion Earth would have been very much like in recent Mars. Even its radius would have been that of recent Mars! One can ask whether GOE forced the existing primitive lifeforms underground or saved only those already living underground. Situation would have been be very much like in the recent Mars, which also seems to possess undergound life.

The development of HIF proteins (hypoxia inducing factor) making possible for stem cells to survive in environments with varying and thus temporarily higher oxygen content would have been a natural reaction to the dramatic changes in habitat.

What can one say about the emergence of animal life in TGD framework?

1. The rapid evolution leading to the emergence of animals - if it was present - would relate to the quantum criticality associated with the increase of the effective Planck constant $h_{eff}/h_0 = n$ by factor 2 increasing the size scale of Earth. The increase of $h_{eff}/h_0 = n$ might have occurred at several levels of dark matter hierarchy, also at biological relevant scales and led

to an increase of biological "IQ" (note that evolution corresponds in TGD to gradual increase of number theoretical complexity and n characterizes the dimension of extension of rationals characterizing the complexity [L6, L7]).

2. Animals use oxygen for breathing and are multicellular eukaryotes having cell membrane enclosing nucleus and other membrane bound organelles. The quantum critical period could have led to the emergence of a kind of symbiosis of various kind of organelles within cell membrane bounded volume. The p-adic length scale $L(k)$ determined by the value of n assignable to the outer membrane of organelles could correspond to the prime $k = 163$ (or 167). Inside plant cells having no cell membrane these organelles correspond to vacuoles (see `http://tinyurl.com/yd879b2d`). The outer membrane that emerged in the transition increasing h_{eff}/h_0 meant increase of the scale of quantum coherence to a longer p-adic length scale - say $k = 167$ (or $k = 169 = 13^2$ if doubling took place).

3. Mitochondria would have emerged and made possible oxygen based respiration whereas plant like organisms preceding them utilized anaerobic respiration. Methanogenesis (see `http://tinyurl.com/y97gkym8`) utilizing carbon instead of oxygen and producing carbon-dioxide and methane CH_4(water in O_2 based respiration) is the most natural option. The large methane storages underground would be due to methanogenesis.

   The recent findings (see `http://tinyurl.com/y735g9kn`) indicate that there is life in Mars: methane emissions occurring periodically with a period of Martian year have been detected. This suggests that solar radiation is somehow able to enter to the interior of Mars or that it heats the underground Oceans. In TGD one can consider also the possibility that some part of solar photons transforms to dark photons and is able to propagate to the underground oceans through the Martian crust [L9].

4. What was the primary source of metabolic energy? Direct solar radiation was absent in underground oceans. The immediate source of metabolic energy for the plant like organisms might have been dark nuclei consisting of dark proton sequences and liberating energy in the transitions reducing of $h_{eff}/h_0 = n$. Dark proton triplets give rise to dark variants of DNA, RNA, tRNA, and amino-acids [L4, L3, L11]. These dark proton sequences could have formed by Pollack effect at the surface of Earth possibly containing some water and could have propagated along dark flux tubes to the interior: also in "cold fusion" dark nuclei would be formed. Some fraction of them would transform to ordinary nuclei and liberate practically all the nuclear binding energy. Also transitions to dark nuclei with a smaller value of h_{eff}/h_0 is possible and liberates energy usable as metabolic energy. Most dark nuclei could leak out along magnetic flux tubes [L5]. The hen-egg problem - which came first, metabolism or genetic code - would trivialize in this framework.

   For p-adic length scale $L(k = 149) = 5$ nm - thickness of cell membrane - the typical dark nuclear excitation energy was about .5 eV, the nominal value of metabolic energy quantum. For $L(151) = 10$ nm (thickness of neuronal membrane and DNA double strand its value is .25 eV. These estimates are based on the scaling of the typical nuclear excitation energy taken to be 1 MeV and are uncertain by a factor of 2 at least. One of course expects also higher excitation energies - even so high that they correspond to visible ordinary photons. Metabolic energy could have been liberated as dark photons in dark nuclear transitions transforming to ordinary photons and absorbed by the photosynthetic machinery.

   The (rough) estimate for the typical value of the dark photon energy is considerably lower than in ordinary photosynthesis. Pollack effect [L1] occurring in presence of gel phase bounding water volume suggests that for $k = 149$ the transformation of dark proton sequences to ordinary ones: this mechanism would liberate energy per proton ~ 1.5 eV [L8], which corresponds to infrared photon. The small value of the metabolic energy quantum need not be a problem: there is recent evidence that IR light with energy 1.76 eV can be used in photosynthesis (see `http://tinyurl.com/yc6pqjed`).

2.1 Could Mars have intra-martial life?

A popular article in National Geographic (see `http://tinyurl.com/y5unt6y7`) tells about unexpected findings made by the first robotic geophysicist, the Insight lander revealed in the European

Planetary Science Congress and in the American Astronomical Society. There are odd magnetic pulsations with frequency around 10 mHz [?] (see http://tinyurl.com/y3ll8kcg) occurring at Martian night-time: for Earth these pulsations occur in frequency range 1 mHz to 1 Hz. Mars has much stronger magnetic field as expected. The magnetic field was detected at heights 96-400 km.

Besides this there is evidence for the existence for a global electrically conductive layer about 6 km below the surface, which suggest an underground reservoir of water. This has enormous implications for potential existence of life in Mars. There is also earlier evidence for the existence of salty, liquid water measuring about 19 km across (see http://tinyurl.com/ycjaky5g).

The strange findings about Mars can be understood in the framework provided by TGD based model for expanding Earth providing also explanation for the mysterious Cambrian explosion assuming that the life developed in Earth's interior, TGD based notion of magnetic field, and dark matter identified as phases with nonstandard value $h_{eff} = nh_0$ of Planck constant.

2.1.1 Connection with the model of Expanding Earth

These findings bring in mind TGD based model for expanding Earth [L10, L9, ?] (see http://tinyurl.com/yc4rgkco, http://tinyurl.com/yb68uo3y, and http://tinyurl.com/ya68nggs).

1. The observation is that if Earth has radius one half of itse recent radius the continents fit nicely together to cover entire surface of Earth. This lead to the proposal that during Cambrian explosion in which highly developed life formed mysteriously emerged, the Earth radius grew by factor 2 in a relatively short time. The life would have evolved in Mother Gaia's womb, underground oceans perhaps between crust and astenosphere at depth not larger than 80 km, shielded from cosmic rays and meteoric bombardment.

2. The sudden expansion can be modelled in TGD inspired new physics as a phase transition increasing the p-adic length scale of Earth and reducing the scale dependent cosmological constant assignable to Earth by factor 1/4: these kind of phase transitions replace smooth cosmological expansion in TGD inspired cosmology.

   This led to the splitting of the continuous crust to continents and oceans emerged as the water from underground oceans containing the highly developed life forms bursted to the surface.

3. The intriguing coincidence is that Mars has radius which is 1/2 of Earth's recent radius. Could also Mars have underground ocean with rather developed life forms waiting for the moment of birth? Magnetic field is necessary in TGD based model of life and the article tells that Mars has unexpectedly strong magnetic field. It also tells about underground ocean at death about 100 km! The boundary between Earth's core and astenosphere, where the ancient oceans might have been is at dept of about 80 km.

2.1.2 There is something weird in the magnetic field of Mars

The assumption that magnetic field of Mars can be approximated as a dipole field leads to a paradoxical situation in Maxwellian framework.

1. Wikipedia article about Earth's magnetosphere (see http://tinyurl.com/y3t78oka) gives a criterion for the height below which magnetic field can survive under the pressure caused by solar wind. The criterion reads

$$\frac{R_{CF}}{R_P} = \left(\frac{B^2}{\rho_{sw} v_{sw}^2}\right)^{1/6} \quad .$$

   Here R_P is planet radius, B is the strength of the magnetic field at its surface, and ρ_{sw} and v_{sw} are the mass density and velocity of solar wind. The ratio R_{CF}/R_P is essentially the ratio of the density of magnetic energy and density of kinetic energy. This implies that the strength of B is about 10 times higher than the strength of the Earth's magnetic field at surface about .5 Gauss. The recent findings should increase the earlier estimate $R_{CF}/R_P \sim 1$ given in Wikipedia. For Earth the thickness of magnetosphere is about 10 times Earth radius giving $R_{CF}/R_P \sim 11$.

2. The strength of magnetic field behaves like $1/r^3$ in dipole approximation and scaling R_P by factor 2 would reduce magnetic field strength at surface down by factor 1/8, which is near to value of the Earth's magnetic field strength B_E. Could one think that also Earth had similar magnetic field before the expansion an that the expansion of Earth radius by factor 2 gave rise to the recent magnetic field? $B_{Mars} \sim 10B_E$ however suggests that the magnetic field of Mars in dipole approximation should actually extend equally far as the Earth's magnetic field! This does not seem to make sense.

   Could one think that the matter at the flux tubes of Martian magnetic field is dark matter as $h_{eff} = nh_0$ phases and is not visible in the ordinary sense. For instance, cyclotron energies proportional to $h_{eff}eB/m$ would be much higher than expected. Another option is that the magnetic field corresponds carries monopole fluxes at its flux tubes carrying dark particles.

What looks mysterious is that if Martian magnetic field is dipole field in reasonable approximation, it should be more or less like Earth's magnetic field! One would expect cyclotron radiation and van Allen belts. Why they are not seen? The answer could be simple.

1. Also Earth's magnetic field would decompose to stable part for which flux tubes carry quantized monopole flux and ordinary part. Monopole part does not need current to sustain it and this has been used to explain why Earth's magnetic field has not disappeared long time ago. The varying part of the Earth's magnetic field would be created by convection currents in the solar. Since Mars does not have outer core, it would not have this part of magnetic field. I have proposed this model for the maintenance of Earth's magnetic field at [L2] (see `http://tinyurl.com/y5anawyk`).

2. I have assumed that dark matter as $h_{eff} = nh_0$ phases of ordinary matter essential for life resides at the flux tubes of this field having strength which is 2/5 of the Earth's ordinary magnetic field. I have called this field endogenous magnetic field and its existence and existence of h_{eff} hierarchy was deduced from the explanation of quantal effects of ELF em fields on vertebrate brain. If Mars has only dark magnetic field, the magnetic field of Mars could be invisible! The ordinary part of this magnetic field should appear in the analog of Cambrian explosion as the radius of Mars increases to that of Earth and core radius increase by factor 2 and the core becomes unstable against division to two layers.

3. It has been thought that Martian magnetic field is so weak because the outer core of Mars has been seized up in distant past leading to a collapse of the magnetic field. Could one think that the reverse of this process took place for Earth in the expansion and created the outer core, perhaps by splitting of the core to outer and inner core? This picture would fit nicely with the p-adic length scale hypothesis suggesting layered structures with thickness of layer coming as some power of 2: the thickness of core would have double and core would have divided to two layers. If the strength of the Earth's magnetic field has been stronger by factor 8 before Cambrian explosion, this should be seen in magnetic records.

   The rotation of the outer core would create ordinary magnetic field after the expansion. Before that various ions from solar wind would have entered to the dark flux tubes and entered to the interior of Mars. Same would have happened also in Earth and would explain how oxygen atmosphere emerged in Cambrian explosion and life could burst safely to the surface of Mars.

4. Intriguingly, Mars has its own version of Northern lights (see `http://tinyurl.com/y5z7jlkb`). Without magnetic field auroras should not exist! Could it be that they are dark auroras associated with dark magnetic field of Mars. In reconnections of the magnetic field o Martian magnetic field and those associated with solar wind dark ions would transform to ordinary ones and create Norther and Souther lights. Van Allen belts are in the height range .6-58 Mm (Earth radius is 6,4 Mm). Mars should have dark van Allen belts along which ions of solar wind would end down to the interior of Mars.

5. What about the pulsed oscillations of Martian magnetic field at frequency around 10 ms, which corresponds to a period of 3.33... minutes detected at the night-side of Mars?

The pulsations could correspond to a biorhythm. Also Earth's magnetic field has pulsations with frequencies varying between 1 mHz and 1 Hz. 1 mHz corresponds to 3/3.6 minutes and 1 Hz to average DNA cyclotron frequency in endogenous magnetic field $B_{end} = .2$ Gauss identifiable as dark magnetic field.

Could these pulsations correspond to a heartbeat or breathing of Martian magnetic Mother Gaia - rather concrete pulsation of its magnetic body made from flux tubes and/or sheets? Why the pulsations appear only at the dark side? Could the pressure of the solar wind prevent the pulsations at the day-side?

One can wonder what the measured magnetic field is. Is it the sum of dark and ordinary part or only ordinary part. If test particles touch all space-time sheets involved, they experience the sum of the magnetic fields so that the usual measurements should give the sum. If it is only the ordinary part, one would still have the problem why the field having strength near to Earth's magnetic field is not visible as van Allen belts for instance. The QFT limit of TGD indeed corresponds to the replacement of space-times sheets with single region of Minkowski space and the identification of fields as the sums of the induced fields from various space-time sheets.

2.1.3 Intraplanetary life

The new observations allow to make the existing model for intra-planetary life much more details. The following applies to both Earth and Mars.

1. At Earth the multicellular life forms would have emerged in Cambrian explosion suddenly from the Earth interior as its size increased by factor 2. The expansion would be one stepwise cosmic expansion and associated with the decrease of length scale dependent cosmological constant associated with Earth. Same should happen in Mars sooner or later. So that there is no reason to worry. If we destroy our species and many other at the same time, intelligent life forms will develop in Mars.

2. If the multicellular life forms represented intraterrestrial life, photosynhesis and even oxygen based life should have evolved in underground ocean. The breathing animals would be like fishes using the oxygen in water.

3. The dark magnetic flux tubes of planet would served as channels for solar photons propagating as dark photons to the ocean in the interior of the planet. Dark photons would have transformed to ordinary photons (that is bio-photons) and used in photosynthesis making possible chemical energy storage. Photosythesis would have produced oxygen O_2, which would not have been lost to outer space now: a good reason for intraplanetary life when oxygen atmosphere is missing.

   Thus breathing animals would have become possible besides plants like organisms performing the photosynthesis. Also animal-plants doing photosynthesis themselves can be considered. Even we could use the metabolic energy stored chemically in manner analogous to photosynthesis. The machinery is very similar and there is evidence that even humans can use sunlight as metabolic energy. Pollack effect [L1] would be key element here. Pollack effect generates charge separation and thus voltage and this gives rise to a battery.

2.2 Earhquakes and volcanic eruptions as macroscopic quantum jumps in zero energy ontology

In ZEO the signature of "big" (ordinary) state function reduction is the change of the arrow of time at some level of the hierarchy of space-time sheets (selves) and one could start to search evidence for this effect. Also "small" state function reductions are possible and correspond to "weak" measurements. I did not however have the change of the arrow of time in mind when I encountered a highly interesting article "*Cosmic-solar radiation as the cause of earthquakes and volcanic eruptions*" by Jamal Shrair (see `http://tinyurl.com/y3g3khtd`) telling about the findings related to earthquakes and volcanic eruptions challenging the rational mind making its deductions in standard ontology.

1. The occurrence of earthquakes up to 34 kilometers below the surface of Earth and volcanic eruptions up to 9 km below the surface has strong correlation with the sunspot minima (solar activity) and cosmic ray flux. One could think that the system consisting of tectonic plates or magma is critical and sensitive to small perturbations. But how do the cosmic rays get so deep in Earth interior without losing their energy?

   TGD based answer is simple. During sunspot minimum the dark monopole part of the magnetic field of Sun is strong and and the charged particles of solar wind arrive along the flux tubes and by reconnection end up to the flux tubes of the Earth's dark magnetic field (van Allen belts) and along them to the interior of Earth, where they end up to quantum critical system formed by magma or tectonic plates and induces the eruption of earthquake.

2. This however requires that the number of dark monopole flux tubes is large during sunspot minima. Sunspots would be formed in reconnections of very long U-shaped monopole flux tubes coming from Sun and carrying solar wind as dark particles. This would reduce the number of monopole flux tubes but generate ordinary magnetic field by creating currents creating them - monopole flux tubes do not need any current. Therefore the number of monopole flux tubes would be maximal during sunspot minima.

   Quite generally, cosmic rays would arrive to Sun along monopole flux tubes of flux tube network [L13] connecting galaxies and having flux tubes of stellar objects as sub-tangles and continue from Sun to Earth. The highly energetic dark cosmic rays preserving their energy as dark particles could end up to the Earth interior along monopole flux tubes and could induce eruptions and earthquakes. This mechanism would also take dark ions of solar wind to underground oceans in Earth interior in the model of prebiotic life [L10].

Consider now the observations in this framework.

1. In the model of Japanese researchers led by Toshikazu Ebisuzaki cosmic muons are assumed to induce volcanic eruptions. The assumption is that solar magnetic field repulses cosmic rays. When it is weak as believed to be during solar minima, the cosmic rays can arrive to Earth. Volcano would act as a volcanic bubble chamber in which the cosmic rays induce a phase transition (see `http://tinyurl.com/y3d52r7c`). The model however considered only the eruptions not deeper that 10 m below surface rather whereas most eruptions occur at depths up to 10 km. The objection is obvious: for the cosmic muons as ordinary particles it is difficult to get so deep into the interior.

2. NASA researchers reported that earthquakes are preceded by large fluctuations of densities of electrons and other charged particles in the upper part of atmosphere. Perturbations are detected at at heights 100-600 km above Earth's surface. For Earth quakes the depths vary down to 35 km. If cosmic rays induce the earth quakes, one would expect that the time order as indeed proposed by NASA researchers in their model. The problem is that electric perturbations precede the earthquakes rather than vice versa.

   Here ZEO comes in rescue: The time order was indeed opposite. Macroscopic quantum jump of a quantum critical system took place changing the direction of time. There is precise analogy with the findings of Minev et al in atomic systems showing that a deterministic and smooth time evolution seems to lead to the final state of quantum jump [L12] [L12]. The time evolution however has opposite arrow of time and starts from the final state. Libet's findings [**?**] have the same explanation in terms of act of free will realized as state function reduction. Now the "big" state function reduction would correspond to the earthquake/volcanic eruption and would be induced by cosmic rays serving as stimulus. The bad news is that when the electromagnetic fluctuation are detected, the quantum jumps has already occurred and nothing can be done to prevent the catastrophe.

3. In Maxwellian picture one expects that the magnetic pressure of solar magnetic field is minimum during sunspot minimum: just the opposite is true as experiments show (see `http://tinyurl.com/y3g3khtd`! The stronger the solar minimum the stronger the magnetic pressure. This is indeed the case in TGD picture if the detected magnetic field corresponds to the sum of magnetic field associated with monopole flux tubes and ordinary flux tubes!

This is what the QFT limit of TGD predicts since spacetime at this limit carries the sum of induced fields associated with the sheets of the many-sheeted space-time.

These findings inspired the proposal of the article that motivated these comments (see http://tinyurl.com/y3g3khtd): the magnetic pressure of solar wind could induce the earthquake/volcanic eruption somehow but leaves the detailed mechanism open. In TGD this assumption is not needed. The dark cosmic rays from the monopole flux tubes of solar magnetic field reconnected to with similar flux tubes of the Earth's magnetic field would travel along them to the interior of Earth.

4. The article of Shrair also mentions earth lights, which are luminous phenomena associated with the lines of tectonic activity. I have proposed already earlier an explanation in terms of dark photons liberated from the regions with high tectonic stresses. These dark photons could be phase conjugate photons with non-standard arrow of time accompanying mini earthquakes already occurred with respect to subjective time. Even bigger earthquakes could be in question if the irradiation of phase conjugate dark photons with non-standard time direction continues for a long time after the earthquake, which will happen in our geometric future.

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