Updated version of Expanding Earth model

March 9, 2022

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Abstract

This article represents an updated version of the Expanding Earth Model (EEM)based on the assumption that during the Cambrian Explosion (CE) for about .5 billion years ago, the radius of Earth increased by factor 2.

The recent findings demonstrating that the Earth's mantle contains water and even pockets of fluid water plus a detailed discussion of various objections against EEM lead to an updated version of the model. The key assumption is that the size of the atoms was by a factor 1/2 smaller than after the transitions. One can imagine several explanations.

1. The thickening of magnetic flux tubes assignable to condensed matter determining the density of condensed matter should have thickened by factor 2 in the transition. The natural guess for this scale is of order Angstrom. p-Adic length scale $L(137) = 2^{(151-137)/2}L(151) \simeq 1/1.28$ Angstrom is a good guess. The phase transition $k = 137 \to 139$ could have occurred. An estimate for the value of string tension follows from hadronic string tension $T_H = 1$ GeV^2 and gives $T(137) =\simeq 1\ eV^2$. The energy of a string portion with length $L(137)$ is $E(137) \simeq 10$ keV. An energy of this order would have been liberated in the transition $k = 137 \to 139$.

2. There are two options to consider.

   Option I. The transition $h/2 \to h$ would scale atomic binding energies by factor 1/4. For Fe the liberated binding energy would be 53.1 keV. This is huge energy and the assumption that the transition is entropy driven does not look plausible.

   Option II. This option is supported by various experimental anomalies related to valence electrons and the TGD based model for valence electrons. The thickening of the flux tubes would induce a phase transition $h_{eff} \to 2h_{eff}$ for the valence electrons only. Since valence electrons are responsible for chemistry, the resulting atoms would have been effectively dark with respect to the ordinary atoms.

The transition thickening the flux tubes by factor 2 and inducing the scaling $h_{eff} \to h_{eff}$ would have initiated biological evolution. The finding that Earth was already billions of years ago covered by water suggests that this water suffered the transition (Option II) and could leak almost freely into the interior of Earth and because of its relative darkness would have had much lower temperature and pressure than matter around it. Therefore life could evolve in Mother Gaia's womb shielded from cosmic rays and meteoric bombardment.

Contents

1 Introduction

This article was motivated by several articles. The first popular article "Was ancient Earth a water world?" (`https://cutt.ly/fbFqydU` tells that Earth could have been covered by water for billions of years ago. As the Earth cooled, this water later sinked in the interior of Earth as water of crystallization forming underground "oceans". The amount of salty crystal water inside the Earth is estimated to be of the same order of magnitude as in the recent oceans.

The article "Constraining the Volume of Earth's Early Oceans With a Temperature Dependent Mantle Water Storage Capacity Model" [F1] (`https://cutt.ly/wbFqekI`) The model of the article assumes that the water in the mantle and crust is water of crystallization `https://cutt.ly/nbD65jZ`. The water bound on on salt and metal crystals is not chemically bound but forms hydrogen bonds. In heating this water is liberated. For proteins the amount of crystal water can per 50 per cent. Heating leads to a loss of water of crystallization. Cooling induces opposite process and this would have led to the leakage of the water at the surface to the interior, even to mantle, where it bonded with crystals.

The water of crystallization does not however seem to be the only form of water inside Earth. The popular article "Pockets of water may lie deep below Earth s surface" (`https://cutt.ly/4bFqi8M`) told about pockets of exotic solid water - ice VII - in the mantle, which corresponds to the range of depths 610-800 km. The temperature in this range varies between 1300-4000 K and the corresponding thermal is in the range .13-.4 eV. The solid form is made possible by the large pressure.

The article also tells about the presence of freely flowing liquid water in the transition zone between Earth's crust and mantle. This corresponds to the depth range 410-660 km (`https:`

//cutt.ly/4bD0JIr) and temperatures below 1300 K. Underground life is known to exist at surprisingly large depths although high temperature and pressure pose strong constraints.

The popular article "Life Thrives Within the Earth s Crust" published in The Scientist provides a nice summary about what is known (https://cutt.ly/qbD0A0N. From the article one learns that bacteria found at depths reaching 6 km. Fungi (multicellulars differing from animals in that they have chitin in their cell walls) and even animals are found at depths 700-800 m. The article "Anaerobic consortia of fungi and sulfate reducing bacteria in deep granite fractures" [I2] (https://cutt.ly/VbD0Gvb)tells about sulfate reducing bacteria and fungi found at at granite fractures at depth 740 m.

The reason why these articles are so interesting from the TGD point of view, is that they lead to a more detailed version of the TGD inspired Expanding Earth model (EEM) [L9, L8]. EEM predicts that Earth suffered in the Cambrian Explosion (CE) about half billion years ago a relatively rapid expansion during which the radius of Earth increased by factor 2. There are however several objections against this model and the article provides insights allowing to circumvent these objections and supports the original vision.

2 Updated view of EEM

In this section motivations for and objections against EEM are summarized. Also a resolution of objections based on a more precise model for EEMis discussed.

2.1 Motivations for EEM

There are three basic motivations for EEM.

1. The theoretical motivation is that the occurrence of this rapid expansion of Earth fits with the TGD view about cosmological expansion [L12] as rapid phase transitions replacing smooth cosmological expansion of GRT and solve the problem of GRT caused by the fact that astrophysical objects are not found to expand themselves although they participate to expansion by comoving with it.

2. The geological motivation is that the continents seem to fit nicely together to cover the entire Earth if the radius of Earth is 1/2 of its recent radius.

3. Cambrian explosion (CE) (https://cutt.ly/AbFljuv) serves as a biological motivation. CE started roughly 541 million years and lasted about 13 25 million years. During this relatively short period highly advanced multicellular life forms emerged. From the times before this there are only monocellular fossils.

4. Fermi paradox summarizes the empirical fact that there is no evidence for life as we understand it anywhere in the known Universe. One can imagine several reasons for this. A possible TGD based explanation is that life is present in the interiors of planets as it was in the interior of Earth before CE.

The rapid expansion would have broken the crust of Earth to pieces creating continents and the water from the interior of Earth containing multicellular life would have bursted to the surface and created oceans, absent before CE. The rapid evolution would have occurred during CE or already before CE in the "womb of Mother Gaia" in water pockets or even underground oceans shielded from cosmic rays and meteor bombardments.

2.1.1 The effects of Cambrian Explosion in deep mantle

Roughly a year after writing the original version of this article I learned about a possibe new piece of evidence for the TGD view about Cambrian Explosion. The popular article titled "Traces of life in the Earth's deep mantle" in Phys-Org (https://cutt.ly/AAIj7Ss) told about the work of Giuliani et all about discussed in the article "Perturbation of the deep-Earth carbon cycle in response to the Cambrian Explosion" [F2] (https://cutt.ly/wAIko6S).

The sudden emergence of advanced multicellular lifeforms in the Cambrian Explosion (CE) about 540 Ma ago is still one of the great mysteries of mainstream biology. The team led by ETH researcher Andrea Giuliani found in rocks from deep mantle what can be regarded as traces of CE. The proposal is that partly organic material would have been subducted to the deep mantle after CE and changed the isotopic compositions of Carbon and other elements. Also other elements, for instance strontium and hafnium showed a pattern similar to carbon.

The group of Giuliani examined rare diamond-containing volcanic rocks known as kimberlites from different epochs of the Earth's history. These special rocks originate from the lowest regions of the Earth's mantle. The isotopic composition of carbon in about 150 samples of these special rocks was determined. The composition of younger kimberlites, which are less than 250 million years old, was found to vary considerably from that of older rocks. In many of the younger samples, the composition of the carbon isotopes differs significantly from that expected for typical rocks from the mantle.

The isotope ratio $R = {}^13C/{}^12C$ for Carbon in the deep mantle is considerably lower for the kimberlites younger than 250 Ma whereas the value for kimberlites older than 250 Ma is typical mantle value. The values of younger kimberlites are also more variable. More quantitatively, $\delta^{13}C = (R_{sample}/R_{standard} - 1) \times 10^3$ serves as a parameter. For a typical sample from the mantle, the value is $\delta \simeq -5 \pm 1$ per mille whereas for the studied samples δ is in the range [-20.-30] per mille.

The increased subduction caused by plate tectonics of the material from the surface of Earth could explain this. The estimate is that it takes 200 Ma for the material from the surface to reach the lower mantle. In the standard geology, the natural interpretation is that the dramatic increase in the generation of organic matter in CE has reduced the carbon isotope ratio. One must however assume that the partly organic material from the surface should have ended down to the deep mantle along specific routes by subduction.

Is the TGD inspired hypothesis for Cambrian Explosion life consistent with these findings?

1. The proposal is that life evolved in underground oceans ("womb of Mother Gaia") and suddenly emerged to the surface in the CE as highly developed multicellular organisms. CE was caused by a rapid increase of Earth radius by factor 2, which generated bursts of the underground water reservoirs to the surface and created the oceans. The expansion broke the Earth's crust to pieces and led to the emergence of plate tectonics, subduction, and oceans. Note that in Mars this tectonics is not present and the radius of Mars is actually roughly 1/2 of the radius of Earth.

2. The rapid increase of the Earth radius is the TGD counterpart for a smooth increase of Earth radius in cosmic expansion. All astrophysical objects look as if they would not participate in cosmic expansion: this is a mystery in general relativity. In TGD this mystery is resolved by replacing smooth cosmological expansion with a sequence of rapid expansions followed by stationary periods [L9] [L22].

Is the TGD view consistent with the findings of Giuliani et al?

1. The conclusion of Giuliani et al seems undeniable: the isotope decomposition in the mantle changed 200 Ma ago and was caused by the transport of the material affected by CE to the lower mantle.

2. In the TGD framework these findings do not however force the conclusion that life emerged suddenly in CE. Rather, multicellular life was present in the underground oceans before CE but plate tectonics and subduction were absent.

   The increase of the radius of Earth reduced the average density of Earth dramatically, and created the proposed subduction routes to the lower mantle, which dramatically increased the rate of transport of the organic material to the deep mantle.

3. Interestingly, the process analogous to CE appears to have occurred episodically throughout most of Earth's history, with the oldest diamonds that contain eclogitic inclusions forming at roughly 3 billion years (Ga) [F2]. In the TGD framework this suggests that the rapid expansions of Earth have occurred episodically and have led to the emergence of life forms from the interior to the surface and the transport of the material containing organic carbon to the mantle.

2.2 Objections against EEM and their resolution

There are several objections against EEM.

2.2.1 The reduction of density by factor 1/8 is impossible in standard physics

New physics is needed to make so dramatic a reduction of the density possible. The natural assumption is that the thickness of flux tubes of the magnetic body basically responsible for the density of condensed matter increased by a factor 2 and induced the increase of the radius of atomic volume. One can consider two options for what happened at the atomic level.

Option I. The value of h_{eff} labelling dark matter as phases of ordinary matter increased by factor 2, which led to scaling of atomic sizes by this factor and induced the reduction of the density by factor 1/8. The findings of Randel Mills can be explained if one has $h_{eff} = 6h_0$, where h_0 is the minimum value of $h_{eff} = nh_0$. The problem is that the total binding energy of electrons must have been compensated in the transition and it is not clear whether the energy liberated in the thickening of the flux tubes can provide the needed energy.

For Fe, which is also biologically important, the needed energy is for for $h_{eff} = h/2$ about 52 keV and seems quite too large if the string tension of atomic flux tubes is scaled to atomic scale from the hadronic string tension giving energy of order 10 keV per atomic length $L(137)$. The phase transition should have been entropy driven.

Note that in the TGD framework, the second law is implied by the negentropy maximization principle (NMP) for the sum of non-positive entanglement negentropy in the real sector, and the non-negative p-adic entanglement negentropy assignable to cognition. NMP forces the increase of the total entanglement negentropy and its positivity. This also forces the increase of entanglement entropy of ordinary matter. Thus the entropy driven phase transition allowing the emergence of Fe essential for oxygen based life would have meant an increase in negentropy and an evolutionary leap as it indeed meant. $h/2$ option is of course non-realistic but the argument applies also to the second option.

$h/2$ phase could have prevailed only during the period when the temperature was so high that atoms were unstable against ionization for the ordinary value of h. One can argue that as atomic physics with $h_{eff} = h$ became thermodynamically possible, it emerged in a phase transition. The electronic binding energies in question are of order $(Z/n)^2 E_H$, $E_H = 13.6$ eV. For instance, for Ca this temperature is about 2.7×10^8 K and corresponds to the temperature at which nuclear reactions become possible. The possible $h/2$ atomic physics might make itself visible at these temperatures.

Option II. Chemistry, and therefore the density of the condensed matter, is believed to be determined by chemical bonds, in particular by valence electrons. The TGD based view of valence bonds is discussed in [L5, L25]. Could the thickening of flux tubes by a factor 2 have induced the increase of h_{eff} of the valence electrons by a factor 2.

In the sequel these two options will be considered.

2.2.2 How could photosynthesis emerge in the Earth interior?

The animals that emerged in EEM performed photosynthesis. How could photosynthesis emerge inside Earth where ordinary solar light cannot get? I have proposed that dark photons with non-standard value of h_{eff} travelling along magnetic flux tubes managed to reach the evolving life inside Earth.

The recent proposals allow variants of this explanation.

Option I. The solar radiation with $h_{eff}/h_0 = 6$ was dark relative to the environment surrounding the water pockets. Life could have evolved already before or during CE in the water pockets with $h_{eff} = h = 6h_0$ larger than $h_{eff} = 3h_0$ in the environment. Solar photons with $h_{eff} = h = 6h_0$ did not "see" the presence of the environment because via direct interactions describable as Feynman graphs. Only the transformation $h_{eff} = 6h_0 \to 3h_0$ of the solar photon made scattering and absorption possible.

Option II. If the values of h_{eff} for the valence electrons were scaled up by a factor 2 inside the water blobs with flux tubes having thickness twice of those in the environment, and if valence electrons indeed determine what atoms are chemically, the water blobs would have behaved like dark matter relative to environment, and could have survived inside Earth. The dark of the

sunlight having h_{eff} twice the usual value could have travelled freely to the interior of Earth and made possible photosynthesis.

2.2.3 The temperatures in crust and mantle are too high to allow the emergence of multicellular life

One can argue that the temperature in the crust and mantle is too high to allow the presence of multicellular or even monocellular life. However, if the pockets and environment were dark relative to each other, the situation changes. There would have been a very low rate of transfer of energy between these phases. The temperatures of pockets could have been much lower than that of the environment.

The gradual approach to thermal equilibrium characterized at magnetic body (MB) by Hagedorn temperature would have led to "death" of these primitive life forms but the occurrences of ordinary ("big") state function reduction reversing the arrow of time would have meant reincarnation with opposite arrow of time. This would conform with the TGD based view about life based on zero energy ontology (ZEO) [L24].

The original proposal that multicellular life evolved in the Earth's interior already before CE, is consistent with both options. The water at the surface of Earth was present already billions of years ago, and could have been dark in either of the proposed senses so that it could have leaked to the Earth interior and formed pockets with low temperature and low pressure. Note that solar light must have had $h_{eff} = 6$ already at time and for Option I could have induced the h_{eff} changing phase transition for the water molecules and perhaps also of the other molecules at the surface of Earth.

The proposed explanation of the Fermi paradox in terms of intra-planetary life would be nice but the obvious objection is that the circumstances in the interior make chemical life (as we know it) impossible unless some new physics, which allows the thermo-dynamical conditions prevailing at the surface of Earth, is involved.

Option I. Could the dark planets with $h_{eff} = h/2$ contain intra-planetary life as Earth did before CE, so that both the darkness of these planets and the lower evolutionary level of this life would be the reason for the failure to observe this life.

Option II. Also the scaling $h_{eff} \to 2h_{eff}$ for valence electrons could allow dark water blobs inside all planets if one believes that valence electrons dictate chemistry.

2.3 How the reduction of the density of Earth was possible?

The increase of the radius of Earth by a factor of 2 means that the average density is reduced by a factor 1/8 (in the case the system is genuinely 3-D; one can consider also effectively 1-D flux tube spaghetti). In standard condensed matter physics this kind of change in the local density is impossible.

The reason is that the density ρ - and thus the number density $n = \rho/mp$ of nucleons of condensed matter increases slowly with the mass number A (`https://cutt.ly/LbGMu9u`. Only very high pressures and chemical composition involving heavy elements can affect n significantly. For instance, the density of Earth varies from 2.2 g/cm^3 in the crust to 13 g/cm^3 in the inner core (`https://cutt.ly/4bD0JIr`) and therefore roughly by a factor 6.

Interestingly, the density of water is 1 g/cm^3 and by a factor $r < 1/2$ lower than the densities of the components of the crust. The low mass density of water might make it somehow special. Could water be seen as a mixture of phases with varying densities corresponding to varying radii for the flux tubes as suggested in [L10] to explain the numerous thermodynamic anomalies of water. The phases would correspond to different values of $h_{eff} = nh_0$ for flux tubes. The thickness of the flux tube would correspond to the p-adic length scale determined by the p-adic prime identified as a ramified prime associated with the extension.

If the local density at least in the mantle and crust contributing roughly one half to the total mass of Earth remained unchanged, a kind porous structure with pores filling 7/8 of the volume would have been formed. This looks implausible.

It seems that the expansion - if it happens at all - involves new physics.

2.3.1 Does the TGD view about dark matter allow to understand the reduction of the density

The basic prediction of the adelic physics [L6, L7, L1] is the identification of dark matter as hierarchy of phases of ordinary matter with effective Planck constant $h_{eff} = nh_0$.

1. In adelic physics n is interpreted as a degree of polynomial determining the space-time regions which corresponds to the particle. n measures the algebraic complexity of space-time region and serves as a kind of IQ and measure of the scale of quantum coherence. Evolution would corresponds to the increase of algebraic complexity and therefore also to the increase of n.

2. Functional composition of polynomials would give rise to evolutionary hierarchies in which the degree of polynomial at a given level divides the degrees at higher levels [L15, L16]. For instance $n = 3 \to n = 6$ conforms with this picture.

3. $n = 1$ would correspond to the simplest form of matter: the roots of polynomials defining the the space-time region would be rational and if the polynomial is irreducible, it is linear polynomials with rational coefficients. It is not clear whether $n = 1$ phase does exist.

   The phases with different values of n would not have direct couplings with ordinary matter describable in terms of Feynman diagrams. The transformation of particles, say photons, with different values of h_{eff} to each other are however possible and would occur for photons. Biophotons would be ordinary photons resulting from $h_{eff} > h$ dark photons by this kind of transition.

There are two guidelines available.

1. The scaling by factor 2 suggests a transition $h_{eff} \to 2h_{eff}$. Option I and II are possible.

2. The findings of Randel Mills [D1] can be understood if $h_{eff} = h = 6h_0$ holds true for ordinary matter [L4] and in the experiments of Milss a phase with $h_{eff} = 3h_0$ was formed. This would support Option I.

Although it turns out that Option I is not plausible model for CE, the phase transition $h_{eff} = 3 \to h_{eff} = 6$ is interesting as such.

1. This transition could have preceded by a transition $h_{eff} = h_0 \to 3h_0$ of $n = 1$ phase is possible at all. One could imagine a hierarchy in which cosmic strings correspond to $n = 1$ and flux tubes obtained by their thickening correspond to $n > 1$ phases. n cannot however directly relate to the value p-adic length scale characterizing the string like object.

2. Fine structure constant is proportional to $1/h_{eff}$ and would have decreased by a factor $1/2$ from its value before the transition. The atomic binding energy scale would have been 4 times larger.

   If $h_{eff} = 3$ is possible for stars, the radiation from them has an energy spectrum scaled up by factor 4. $h_{eff} = 3$ photons should transform to ordinary $h_{eff} = 6$ photons before interaction with the ordinary matter. The rate for this transformation could be low so that this kind of stars are difficult to observe. Dark matter could therefore be partially also $h_{eff} < 6$ matter.

3. One can ask whether the $h_{eff} = 3 \to 6$ transformation of the planetary matter near the planetary surface was induced by the interaction with solar radiation. The second question is whether it took place for each planet independently or whether a collective phase transition in cosmological scales occurred. The minimal assumption is that this transition is part of the evolution of the astrophysical object and those objects for which it has not occurred are dark relative to us.

   $h_{eff} < h$ phase would represent only one form of dark matter when darkness is regarded as a relative notion. Valence electrons would also represent dark matter with $h_{eff} = h_{em} > h$ as also dark protons assignable to hydrogen bonds. Another form would be the Kähler magnetic and volume energy and possibly dark particles at cosmic strings transformed to flux tubes. This includes the dark matter satisfying Nottale hypothesis $h_{eff} = h_{gr} = GMm/v_0$ and associated with gravitational flux tubes [E1].

4. Both planets and observed exoplanets must have $h_{eff} = 6$ since the reflection of solar light from the surface is expected to be occur only if the $h_{eff} = 6$ stellar photons transform to $h_{eff} = 3$ photons. Note that the known exoplanets belong to the Milky Way whose size is about 50,000 ly and much shorter scale than the 500 million ly defined by the time of CE.

5. Planet 9 (`https://en.wikipedia.org/wiki/Planet_Nine`, whose existence has been proposed because its gravitational field could explain the unusual clustering of orbits for a group of extreme trans-Neptunian objects (ETNOs), bodies beyond Neptune that orbit the Sun at distances averaging more than 250 times that of the Earth. Planet 9 is too distant to be seen directly. Witten has proposed an interpretation as a blackhole [E2]. An alternative identification would be as an $h_{eff}/h_0 < h$ object.

6. The $h_{eff} = 6h_0$ life in the interiors of $h_{eff} = 3$ planets could be considered as a possible solution of the Fermi paradox. In the proposed model, the life below the surface of Mars would be possible only near its surface and mono-cellular as most of the life in the Earth's crust.

2.3.2 Cambrian explosion as a quantum jump in a planetary scale?

In ZEO [L14, L18] based quantum measurement theory, there are two kinds of state function reductions (SFRs): "big" (ordinary) state function reductions (BSFR), which involve time reversal and "small" SFRs, which correspond to "weak" measurements in which the arrow of time is preserved. The sequence of SSFRs defines a conscious entity and aBSFR can be regarded as death in a universal sense.

In biology BSFR [K3] [L24, L23] corresponds to the death of subsystem and its re-incarnation with an opposite arrow of time occurring at the level of magnetic body (MB) of the system controlling it because of this higher IQ due to the much larger value of h_{eff}. h_{eff} hierarchy predicts that quantum coherence and SFRs are possible in all scales at the level of MB.

Although BSFR is discontinuous, it looks for an observer with a standard arrow of time (briefly, "outsider") like average over deterministic time evolutions leading to the final state of BSFR. In the ZEO framework, the Universe looks therefore classical in all scales.

Could CE correspond to BSFR, or actually two BSFRs to achieve original arrow of time - at the level of MB? The duration of the average deterministic classical time evolution of this BSFR seen by an outsider would be about 13-25 million years.

What CE as BSFR could look like for an outsider?

1. Water has a unique role in biology since living matter consists mostly of water. In TGD inspired quantum biology it is seen as a primitive life form preceding chemical life. For instance, water memory would be behind the immune system [K2].

   Pollack effect [I1, I6, I5], associated with water irradiated in the presence of gel phase and leading to the formation of negatively charged exclusion zones (EZs), would be behind charge separation associated with cell, DNA, and microtubules. Part of protons would become dark and would be transferred to magnetic flux tubes where they could give rise to a fundamental representation of genetic code [L3, L11]. An attractive assumption is that the phase transition thickening the flux tubes by factor of 2 occurred first for the water phase. The density of water is one half of that from that for the density of the crust and this could be understood if water consists of flux tube-like structures.

2. Since solar radiation was present already billions of years ago and also Earth was covered by water, it is possible that the solar radiation induced the phase transition for water at the surface of Earth. Call this water activated water.

   For both Options I and II, the electromagnetic interactions of the activated water with the matter of primordial Earth were very weak and it could leak to the Earth interior - not as a crystal water but as pockets with much lower temperature and pressure inside Earth. The solar radiation also reached the interior of the Earth so that an evolution leading to photosynthesis and metabolic machinery could have indeed occurred in the interior in the womb of Mother Gaia.

Note that the TGD based model for valence bonds [L5] requires that solar radiation corresponds to several values of h_{eff} or that the transitions of $h_{eff} = 6 \to h_{eff} > h$ are possible.

3. Pollack effect could have led to the formation of the basic structures of the chemical life inside these pockets. The flux tube connections with large h_{eff} between pockets could have formed and made possible larger structures consisting of separate units and controlled by its MB. Even underground oceans can be imagined.

4. One can consider two options for the evolution of multicellulars. According to the original option, multicellular life evolved already before CE. The standard view about CE is that it occurred during CE. In the TGD framework, the original option looks more plausible. The emergence of life would mean a scaling $h_{eff} \to 2h_{eff}$ for valence electrons (Option II) $h_{eff} = 3 < h$. Scaling $h/2 \to 2h$ for all electrons (Option I) looks implausible. Maybe the liquid phase and low density could allow to understand why.

2.4 The transition increasing flux tube thickness as a phase transition induced by magnetic body

There are two options to consider: I and II. Option I assuming that the thickening of flux tubes by factor 2 induces the phase transition $h/2 \to h$ does not seem realistic. It is however possible that this phase transition has occurred much earlier at temperatures allowing nuclear fusion and could also occur in the laboratory in these circumstances.

The following discussion applies to both options: the only difference is that the total electron binding energy E_B is replaced with that for valence electrons.

The best manner to proceed is to develop objections against the proposals. It is easy to develop a rather scaring objection.

2.4.1 Minimization of free energy as basic principle

The minimization of free energy F can be taken as a basic principle since temperature is expected to remain constant during the phase transition.

1. If the temperature stays constant in the transition,the basic thermodynamic condition is that free energy decreases

$$\Delta F = \Delta E - T\delta S \leq 0 \ . \tag{2.1}$$

2. One can express ΔE as

$$\Delta E = \Delta E_B + \Delta E_{MB} \ . \tag{2.2}$$

The subscript "B" refers to the binding energy which for Option I is the total binding energy $E_B = E_{B,atom}$ and for Option II the total binding energy $E_{B,val}$ of valence electrons. The subscript "MB" refers to the magnetic body assignable in the TGD framework to magnetic flux tubes, whose thickening by a factor 2 would liberate energy and kick the atoms to new ground states.

3. From the $1/h_{eff}^2$ proportionaly of the binding energies, the reduction of the binding energy in the transition is given by

$$\Delta E_B = \frac{3E_B}{4} \ . \tag{2.3}$$

The thickness of the flux tube is expected to correspond to the atomic length scale of order Angstrom so that atomic physics would involve a new length scale relevant for the density of condensed matter.

$$\Delta E = \Delta E_{B,tot} + \Delta E_{MB} \quad . \tag{2.4}$$

4. One can express ΔS in an analogous manner

$$\Delta S = \Delta S_{atom} + \Delta S_{MB} \quad . \tag{2.5}$$

The subscript "atom" refers to entropy assignable to scaledup atoms and "MB" to magnetic body.

One can consider two manners to satisfy this condition depending on whether the transition is energy or entropy driven.

1. For $\Delta S = 0$, one has $\Delta E \leq 0$. This would mean that the energy needed to kick electrons to new states with binding energy reduced by factor $1/4$ must come somewhere. The fundamental quantum phase transition at MB should provide it, most naturally as energy liberated when the string tension of flux tubes is reduced as they thicken.

2. The alternative option is that that the transition develops a lot of entropy

$$\Delta S \geq \frac{\Delta E}{T} \quad . \tag{2.6}$$

It is important to note that in the TGD framework negentropy maximization principle (NMP) is the basic principle and implies second law for ordinary matter.

The p-adic contribution to entanglement negentropy coming from cognition ispositive unlike real contribution, which is non-positive. NMP implies that in adelic physics p-adic contribution to negentropy exceeds in general real contribution. The generation of p-adic negentropy however forces also a generation of real entropy and this conforms with the paradoxical proposal of Jeremy England that living systems produce entropy.

In the recent case the generation of large entropy at the level of visible matter would correspond to a generation of large p-adic negentropy assignable to the MBs in question. Hence the Cambrian phase transition would mean a cognitive revolution of some kind.

2.4.2 Estimates for the total binding energy

The following rough estimates assume Bohr model. In Bohr model, the atomic energies at a given shell n, which corresponds to the row of the Periodic Table. The energy shell contains n^2 states with angular momenta $l = 0, .., n-1$ are given by $E_n = (Z^2/n^2)E_H$. The number of states in full shell is $2n^2$. Full shells are realized only for $n = 1, 2$. The total binding energy in a full shell is nZ^2E_H, $E_H \simeq 13.6$ eV.

One could naively argue that the filling of all sub-shells l is energetically more favorable since the total binding energy would be maximized in this manner. However, already for $n > 3$ only the 8 states at s and p subshells are realized and d shell is missing so that the $n = 3$ shell contains the same angular momentum eigenstates as $n = 2$ shell. For $n = 3$ shell Argon corresponds to configuration $[Ne]s^2p^6$. K does not correspond to$[Ne]s^2p^6d$ but to [Ar]4s. The reason for this is not clear to me and one can of course ask whether the $h/2 \to h$ could have favored smaller binding energies and even led to the increase of n instead of full shell.

The expression for the total binding energy is given by

$$E_B = \sum_n N_n \frac{Z^2}{n^2} E_H \quad , \quad E_H = 13.6\ eV \quad . \tag{2.7}$$

For full shells (the rows $n = 1, and 2$) $N_n = 2n^2$ and the energy is $2Z^2$.

The following equations represent the total binding energies in Bohr model for some important ions in biology.

$atom$	Z	$configuration$	E_B/E_H	E_B/keV	$\lambda/$
O	8	$[He]2s^2 2p^4$	$8^2(2+3/2) = 224$	3.05	4.1
P	15	$[Ne]3s^2 3p^3$	$15^2(2+2+5/9) = 1025$	13.9	.9
Ca	20	$[Ar]4s^2 = [Ne]3s^2 p^6 4s^2$	$20^2(2+2+8/9+1/8) = 2050 - 400/9 \simeq 2005.6$	27.3	.45
Fe	26	$[Ar]3d^6 4s^2$	$26^2(2+2+14/9+1/8) = 3840.1$	52.2	.22

(2.8)

Note that Bohr radius is .53 so that for Ca the wavelength defined λ defined formally by the total binding energy is rather near to Bohr radius. The energies are rather high. For valence electrons the total binding energies are much lower and for Fe one has $E_{val}(Fe) = 1.15keV$.

These results support the view that Option II is more realistic than Option I.

1. The flux tubes are characterized by a p-adic length scale L_p, where p-adic length scale hypothesis states $p \simeq 2^k$. One has $L_p \equiv L(k) \simeq 2^{(k-151)/2} L(151)$, $p \simeq 2^k$, $L(151) \simeq 10$ nm. p-adic length scale $L(137) = 2^{-7} L(151)$, corresponds to .78 and $L(139)$ to 1.56 .

2. The magnetic flux tubes assignable to condensed matter and determining the density of the condensed matter should have thickened by a factor 2 in the transition. The phase transition $k = 137 \to 139$ is a natural candidate. Note that this pair defines twin primes.

   An estimate for the value of string tension follows from the hadronic string tension $T_H \simeq 1$ GeV^2, which corresponds to $k = 107$: this gives $T(137) = 2^{-137-127} T_H = 2^{-30} T_H \simeq 1eV^2$. The energy of a string portion with length $L(137)$ is $E(137) \simeq 10$ keV. An energy of this order would would be been liberated in the transition $k = 137 \to 139$.

3. Option I does not look realistic. From **Eqs. ??** one finds that for Ca the total binding energy is 27.3 keV. For Fe the energy is 46.1 keV. These energies are too large: the transition in the case of Fe should be strongly entropy driven.

4. Option II looks more reasonable. For Fe the total binding energy assignable to the valence bonds is $E_{val} = 1.2$ keV. The maximal binding energy of valence electrons is $Z^2(n^2 - 1)/n^2 E_H \simeq Z^2 E_H$. Not all angular momentum subshells are however filled and this energy is maximum for atoms towards the right end of the row and for Krypton one has $n = 3$ is $D_{val} = 1.1$ keV. 1.24 keV corresponds to the energy of a photon with a wavelength of 1 Angstrom, qhixh looks also reasonable. Since the energy liberated from the flux tube portion is considerably higher than E_{val}, it would have induced expansion.

2.4.3 What could one say about the phase transition at the level of MB?

The phase transition at the level of MB induces the phase transition at the lower levels. Can one say anything about the phase transition at the level of MB?

1. The twistor lift of TGD predicts that energy of the magnetic flux tube is a sum $E = E_1 + E_2$ of two terms.

   The first term is a volume term proportional to the TGD counterpart of cosmological constant Λ predicted to be length scale dependent and by dimensional considerations proportional to $1/L_p^2 G$. Λ would be reduced by a factor 1/4 in the proposed transition transitions. This terms gives a contribution

   $$E_1 = aSL \quad ,$$

   where S is the transversal area of the flux tube and L its lengthThe scaling $a \to a/2$ would occur in the transition.

The energy also contains Kähler magnetic energy. If the flux tube carriesmonopole flux, the contribution is of form

$$E_2 = \frac{b}{S}L \ ,$$

Assume that the scaling $b \to b/2$ occurs in the transition.

2. The minimization of the total energy

$$E = E_1 + E_2 = aS + \frac{b}{S} \tag{2.9}$$

with respect to S is assumed and gives

$$E = 2\sqrt{ab} \ . \tag{2.10}$$

In the scaling the energy transforms as $E \to E/2$. The liberated energy $E/2$ could be used to reduce the binding energy of the atoms by $3E_B/4$.

3. The natural expectation is that the total energy for a flux tube portion of length L_p is of order of photon with a wavelength L_p. This energy is given by $E = \hbar/L_p = 1.24/L_p/\mu m$. For $k = 137$ this gives energy $E \simeq 16$ keV. For Ca one has $3E_B/4 = 20.5$ keV and for P one has $3E_B/4 = 10.3$ keV.

This suggests that the first phase transition could take place only for the biologically important atoms and molecules formed from them - in particular water molecules - and would not produce much entropy. Second phase transitions identifiable as Cambrian explosion would take place for heavier atoms and require large ΔS in turn requiring large generation of negentropy at the level of MB. This would accompany a rapid evolution of life at the surface of Earth.

3 Cambrian explosion, the Great Oxidation Event, and Expanding Earth hypothesis

I encountered two interesting articles related to the Great Oxidation Event that started long before the Cambrian Explosion (CE) and reached its climax during CE (about 541 million years ago) leading to the oxygen based multicellular life in a very rapid time scale.

The standard view is that oceans before CE had very low oxygen content. The emergence of photosynthesizing cyanobacteria producing oxygen as a side product led to the oxygenation of the atmosphere and to mysteriously rapid evolution of life. How this is possible at all is not understood.

The first popular article (`https://cutt.ly/UQWZA31`) discusses the proposal [I4] that the slowing down of the spinning of Earth was somehow related to this. The idea is that the lengthening of the day made photosynthesis by cyanobacteria more effective since their reaction to the dawn of the day was slow. The second article in Quanta Magazine (`https://cutt.ly/PQWZDzD`) tells about the finding [I3] that during the Cambrian Explosion (`https://cutt.ly/1QWZF4E`) the oxygen content of the studied shallow ocean showed fluctuations with with about 4-5 peaks. The reduction/increase of the oxygen content was even 40 per cent, which is a huge number. The reduction of oxygen content caused extinctions and its increase was accompanied by the emergence of new species. The mystery is how this could happen so fast and which caused the fluctuations.

3.1 Expanding Earth hypothesis

Expanding Earth theory hypothesis is not originally TGD based but TGD provides its realization. The proposal is that the Cambrian Explosion was caused by a rapid increase of the radius of Earth by factor 2 [L9, L22].

This hypothesis also solves one of the basic mysteries of cosmology. Astrophysical objects participate in cosmological expansion by comoving with it but do not expand themselves. Why? The prediction that the expansion of the astrophysical objects did not occur smoothly but as rapid phase transitions and the expansion was very slow in the intermediate states. Cambrian Explosion would correspond to one particular jerk of this kind in which the radius of Earth grew by a factor 2 (p-adic length scale hypothesis). The length of the day increased by factor 4 from conservation of angular momentum. This might relate to the conjecture of the first article.

The rapid expansion led to the breakage of the Earth crust and to the birth of plate tectonics. It also led to the burst of underground oceans to the surface of the Earth. The photosynthesizing multicellular life had developed in these oceans and emerged almost instantaneously and led to a rapid oxygenation of the atmosphere. One can say that life evolved in the womb of Mother Gaia shielded from meteorites and cosmic rays. No superfast evolution was needed. Already Charles Darwin realized that the sudden appearance of trilobites was a heavy objection against the theory of natural selection.

Possible scenarios for the phase transition are discussed in [L22]. The thickening of magnetic flux tubes for water blobs at the surface of Earth led to the increase of the volume of water blob and induced the increase of h_{eff} a factor 2 for valence electrons but not for the inner electrons. Since valence electrons are responsible for chemistry, atoms became effectively dark and the water blobs could leak to the interior of Earth. By their darkness they could have much lower temperature and pressure than the matter around them and the life could evolve.

3.2 How photosynthesis was possible underground?

What made photosynthesis possible in the underground oceans? One possible explanation is that the photons from the Sun propagated along flux tubes of the "endogenous" part of the Earth's magnetic field as dark photons with $h_{eff} = nh_0 > h$. Endogenous part would be the part of Earth's magnetic field with a strength about 2/5 of the Earth's magnetic field for which flux tubes carry monopole flux: this is possible in TGD but not in Maxwell's theory.

Since these photons behave like dark matter with respect to the ordinary matter, they were not absorbed considerably and reached the water blobs (or actually their magnetic bodies consisting of flux tubes) in underground oceans having a portion with the same value of $h_{eff} \geq h$. Of course, several values of h_{eff} were possible since this is the case in quantum critical system (large values of h_{eff} characterize the quantum scales of long range fluctuations). One can also consider other variants of the model. The ordinary matter in Earth's crust had $h_{eff} = h/2$ and photons with $h_{eff} = h$ propagated to the interior and reached the water blobs with $h_{eff} = h$.

3.3 The sudden emergence of multicellulars and oxygen fluctuations

Before the expansion period was much like the surface of Mars now and contained no oceans, perhaps some ponds allowing primitive monocellular lifeforms. As the ground of Earth broke here and there during the rapid expansion period, lakes and oceans were formed at the surface of Earth. The multicellulars bursted to these oceans and oxygenation of the atmosphere started locally.

Since the oxygen rich water was mixed with the water in the shallow oceans, the local oxygen content of the burst water was reduced and this led to an eventual extinction of many multicellulars in the burst. Burgess Shale fauna contained entire classes, which suffered extinction. In the average sense the oxygen concentration increased and led to the apparent very rapid evolution of multicellulars, which had actually already occurred underground. Of course, also evolution at the surface of Earth took place.

4 Has venus turned itself inside-out and why its magnetic field vanishes?

News about unexpected findings relating to the physics of astrophysical objects emerge on an almost daily basis. The most recent news (`https://cutt.ly/YQSZgpv`) told about the lack of craters and volcanic activity in Venus (`https://cutt.ly/wQSZzaS`). The findings are actually not new. The resurfacing history of Venus was summarized 1979 by Schaber et al [E3] . Turcotte and

Rome have proposed cyclic global catastrophic events as an analog of the plate tectonics allowing a heat transfer from the interior of Venus and effectively turning Venus inside out [E4].

The Venus does not have appreciable magnetic field although dynamo mechanism suggests magnetic field as in the case of Earth, has been also known.

4.1 Has Venus turned itself inside-out?

The surface of Venus was expected to have craters, just like the surface of Earth, Moon, and Mars but the number of craters is very small. The surface of Venus also has weird features and many volcanoes. Also trace signs of erosion and tectonic shifts were found. The impression is that the surface of Venus had been turned inside out in a catastrophic event that occurred about 750 million years ago.

Since Venus is our sister planet with almost the same mass and radius, it is interesting to notice that the biology of Earth experienced the Cambrian explosion 541 million years ago.

1. The TGD explanation for Cambrian Explosion relies on Expanding Earth Model (EEM) [L9, L8, L22]. The model assumes that there was a relatively fast increase of the Earth's radius by factor, which led to the burst of underground oceans to the surface of the Earth and led to the formation of oceans. Standard cosmology predicts a continuous smooth expansion of astrophysical objects. Contrary to this prediction, astrophysical objects do not seem to expand smoothly. In the TGD Universe, the smooth expansion is replaced by rapid jerks and the Cambrian Explosion would be associated with this kind of phase transitions.

2. In this expansion the multicellular photosynthesizing life burst to the surface. This explains the sudden emergence of highly evolved life forms during the Cambrian Explosion that Darwin realized to be a heavy objection against his theory.

3. There are many objections to be circumvented. For instance, how photosynthesis could evolve in the underground ocean. Here TGD views dark matter as $h_{eff} = nh_0$ phases of ordinary matter, which are relatively dark with respect to each other, come in rescue. Dark water blobs could leak into the interior of Earth and the solar light possessing a dark portion could do the same so that photosynthesis became possible [L22].

4. Did Venus experience a similar rapid expansion 200 million years earlier, about 750 million years ago (or maybe roughly at the same time). Venus does not have water at its surface. This can be understood in terms of heat from solar radiation forcing the evaporation of water and subsequent loss. This also prevented the leakage of the water to the interior of Venus. If there were no water reservoirs inside Venus, no oceans were formed. The cracks of the crust created expanding areas of magma, which were like the bottoms of the oceans at Earth. Also at Earth a fraction about 2/3 of the Earth's surface is sea bottom.

4.2 Why does Venus not possess a magnetic field?

Venus also offers a second puzzle. Venus does not have an appreciable magnetic field although it has been speculated that it has had it (`https://cutt.ly/VQSZt9m`). The solar dynamo mechanism would suggest its presence.

1. TGD predicts that there are two kinds of flux tubes carrying Earth's magnetic field B_E with a nominal value of .5 Gauss. This applies quite generally. The flux tubes have a closed cross section - this is possible only in TGD Universe, where the space-time is 4-surface in $M^4 \times CP_2$. The flux tubes can have a vanishing Kähler magnetic flux or non-vanishing quantized monopole flux: this has no counterpart in Maxwellian electrodynamics.

   For Earth, the monopole part would correspond to about .2 Gauss - 2/5 of the full strength of B_E.

2. Monopole part needs no currents to maintain it and this makes it possible to understand how the Earth's magnetic field has not disappeared a long time ago. This also explains the existence of magnetic fields in cosmological scales.

The orientation of the Earth's magnetic field is varying. In the TGD based model the monopole part plays the role of master. When the non-monopole part becomes too weak, the magnetic body defined by the monopole part changes its orientation. This induced currents refresh the non-monopole part [L2]. The standard dynamo model is part of this model.

3. There is an interesting (perhaps more than) analogy with the standard phenomenological description of magnetism in condensed matter. One has $B = H + M$. H field is analogous to the monopole part and the non-monopole part is analogous to the magnetization M induced by H. $B = H + M$ would represent the total field. If this description corresponds to the presence of two kinds of flux tubes, the TGD view about magnetic fields would have been part of electromagnetism from the beginning!

   Flux tubes can also carry electric fields and also for them this kind of decomposition makes sense. Could also the fields D, P, and E have a similar interpretation?

   In the linear model of magnetism, one has $M = \chi H$ and $B = \mu H = (1+\chi)H$. For diamagnets one has $\chi \leq 0$ and for paramagnets $\chi \geq 0$. Earth would be paramagnetic with $\chi \simeq 3/2$ if the linear model works. χ is a tensor in the general case so that B and H can have different directions.

4. All stars and planets, also Venus, correspond to flux tube tangles formed from monopole flux tubes. This leaves only one possibility. Venus behaves like a super-conductor and is an ideal diamagnet with $\chi = -1$ so that B vanishes. The monopole part would be present however.

   This could provide a totally new insight to the Meissner effect and loss of superconductivity. In TGD the based model [L17], monopole flux tubes carry supracurrent. The BCS model however requires the absence of a magnetic field. Could the induced non-monopole field cancelling the monopole part. Venus would indeed be a superconductor!

5. The TGD based model of superconductivity [L17] also predicts superconductivity driven by an external energy feed would be also above critical temperature. The energy feed would increase the value of h_{eff} and below the critical temperature it would be provided by the energy liberated in the formation of Cooper pairs, which need not actually be the current carriers since dark electrons can carry the current without dissipation. In TGD inspired biology and quite universally, the basic role of metabolic energy feed is to prevent the reductions of the values of h_{eff}.

   Superconductivity means in the TGD framework large h_{eff} and therefore complexity, intelligence, and long quantum coherence length [L25]. Could Venus be alive but in a very different sense than Earth?

6. Could the superconductivity be forced by the thermal energy feed from the interior of Venus? The tilt of the rotation axis relative to the plane of rotation around the Sun is very small for Venus, about 3 degrees and much smaller than for the Earth. This implies that the surface temperature of Venus is roughly constant. At Earth plate tectonics makes possible the heat transfer from the interior to the surface and its leakage to outer space. For Venus this is not possible. Could the energy flow from the interior of Venus force the superconductivity by increasing the values of h_{eff}. This would in turn force the vanishing of the magnetic field of Venus.

7. Sun has an enormous feed of metabolic energy from the core: could it be alive? Also in the case of Earth, the energy feed from the interior could have been crucial for the development of life in the interior of Earth and made possible even the development of photosynthesis.

   The possibility that life actually appears in cosmic scales and is associated with quantum coherent flux tube networks associated with the active galactic nuclei usually identified as supermassive blackholes containing stellar and planetary systems as tangles is suggested by the TGD based model of galactic jets [L21] explaining also ultrahigh energy cosmic rays. The model inspires the proposal that active galactic nuclei having typically sizes 1-2 AU (!) involve gravitationally quantum coherent regions of radius at most of the Schwartschild radius defining a minimal gravitational Compton length [L21].

8. Also Mars lacks the global magnetic field although it has auroras assigned with local fields. Could also Mars be alive in the same same sense as Venus? Note that the recent radius of Mars is about 1/2 of Earth's radius. If Venus expanded by factor 2, all these 3 planets would have had roughly the same radius for about 750 million years ago. Mars would be waiting for the moment of expansion.

4.3 Could superionic phase of water give rise to planetary super-conductivity and Meissner effect?

A superionic ice-like phase of water at high temperature and pressure (20 GPa but much less than the expected pressure, which is higher than 50 GPa) has been discovered. Inside Earth, 20-25 GPa pressure exists in the transition zone between upper and lower mantle. The new phases, bcc and fcc cubic lattices emerge at T=2000 K. See the the popular article "*Scientists find strange black 'superionic ice' that could exist inside other planets*" (`https://www.eurekalert.org/news-releases/933099`) and the article "*Structure and properties of two superionic ice phases*" of Prakapenka et al [D2] (`https://cutt.ly/7TPvYlL`).

The bonds between hydrogen atoms and oxygen ions are broken in this phase and ionized hydrogen atoms form a fluid, a kind of proton ocean in which the oxygen lattice floats.

In the TGD framework dark proton sequences with effective Planck constant $h_{eff} \geq h$ at monopole magnetic tubes play a key role in quantum biology. Dark DNA codons would be 3-proton triplets at monopole flux tubes parallel to DNA strands and would give rise to a fundamental realization of the genetic code.

One can wonder whether the protons of this superionic could be dark in the TGD sense and reside in monopole flux tubes. Could they form a superfluid-like or superconductor-like phase by a universal mechanism which I call Galois confinement, which requires that the total momenta of composites of dark protons with are algebraic integer valued momenta are ordinary integers in suitable units (periodic boundary conditions) [L19, L20].

It is conjectured that this kind phase could reside in the interiors of Neptune and Uranus perhaps even deep inside the Earth. Could superionic phases of water in the interior of planets like Mars and Venus give rise to the speculated super-conductivity implying the vanishing of large scale magnetic field via the TGD variant of the Meissner effect?

Could superionic ice appear in the interior of Earth? Could one consider the following scenario?

Primordial Earth had a vanishing magnetic field by the Meissner effect caused by superionic ice. Part of the superconducting superionic water melted and formed ordinary water at lower temperature and pressure and gave rise to underground oceans. Superconductivity was lost in the Earth scale but the monopole flux based magnetic field and the ordinary magnetic field induced by the currents that it generated remained but did not cancel each other anymore. In the transition increasing the radius of Earth by factor 2 during the Cambrian explosion the water in these oceans bursted to the surface of Earth.

4.3.1 Earthquakes that should not occur

There is an interesting finding, which seems to relate to the superionic ice. It has been discovered that there are earthquakes much deeper in the interior of Earth than expected (`https://cutt.ly/VTSEe5j`). These earthquakes are in the transition zone between upper and lower mantle and (the depth range 410-620 km) even below it (750 km). The pressure range is 20-25 GPa. The temperature at the base of the transition zone is estimated to be about 1900 K (`https://cutt.ly/jTSWxbA`). This parameter range inspires the question whether superionic could emerge at the base of the transition zone and whether the appearance of hydrogen as liquid in pores could make possible the earthquakes below the transition zone just as the presence of ordinary liquid in pores is believed to make them possible above the transition zone.

In the crust above 20 km depth the rocks are cold and brittle and prone to breaking and most earthquakes occur in this region. At deeper the rocks deform under high pressures and no breaking occurs. Deeper in the crust the matter is hotter and pressure higher and breaking does not occur easily.

Around a depth of 400 km, just above the transition zone, the upper mantle of the rock consists of olivine, which is brittle. In the transition zone olivine is believed to transform to wadsleyite

and at deeper depth ringwoodite. At 680 km, where the upper mantle ends, ringwoodite would transform to bridgmanite and periclase. The higher pressure phases are analogous to graphite, which deforms easily under pressure and does not break whereas olivine is analogous to diamond and is brittle.

One can understand the earthquakes down to 400 km near the upper boundary of the transition zone in terms of the model in which water in the proposed upper mantle is pushed away from the pores by pressure, which leads to breaking. Below this depth water is believed to be totally squeezed out from the pores so that mechanism does not work. The deepest reported earthquake occurs at a depth 750 km and looks mysterious. There are several proposals for its origin.

The area of Bonin island is a subduction zone and it has been proposed that the boundary between upper and lower mantle is at a larger depth than thought. The cold Earth crust could allow a lower temperature so that matter would remain brittle since the transition to high pressure forms of rock would not occur. Another proposal is that the region considered is not homogenous and different forms of rock are present. Even direct transition of olivine to ringwoodite is possible and it has been suggested that this could make the earthquakes possible.

4.3.2 Could superionic ice and earthquakes relate?

TGD allows us to consider the situation from a new perspective by bringing in the notions of magnetic flux tubes carrying dark matter. Also the zero energy ontology (ZEO) might be highly relevant. The following represents innocent and naive questions of a layman at the general level.

1. ZEO inspires the proposal that earthquakes correspond to "big" state function reductions (BSFRs) in which the arrow of time at the magnetic body of the system changes. This would explain the generation of ELF radiation before the earthquake although one would expect it after the earthquake [L13].

   The BSFRs would occur at quantum criticality and the question is what this quantum criticality corresponds to. Could the BSFR correspond to the occurrence of a phase transition in which the superionic ice becomes ordinary water? If this is the case, the transition zone, and also a region below it, would be near quantum criticality and prone to earthquakes.

2. The dark magnetic flux tubes are 1-D objects and possess Hagedorn temperature T_H as a limiting temperature. The heat capacity increases without limit as T_H is approached. Could a considerable part of thermal energy go to the flux tube degrees of freedom so that the temperature of the ordinary matter would remain lower than expected and the material could remain in a brittle olivine form.

3. Could the energy liberated in the earthquake correspond to the dark magnetic energy (for large enough value of h_{eff} assignable to gravitational magnetic flux tubes) assignable to the flux tubes rather than to the elastic energy of the rock material? Could the liberated energy be dark energy liberated as h_{eff} decreases and flux tubes suddenly shorten? Could this correspond to a phase transition in which superionic ice transforms to an ordinary phase of water?

One can also ask more concrete questions.

1. Suppose that water below the transition zone (P$\geq$ 20 GPa and T $\geq$ 1900 K) can exist in superionic ice containing hydrogen ions in liquid form. Could the high pressure force the superionic liquid out from the pores and induce the breaking?

2. In the range 350-655 km, the temperature varies in the range 1700-1900 K (`https://cutt.ly/jTSWxbA`). The temperature at the top of transition zones would be slightly above 1700 K. Could regions of superionic ice appear already at 1700 K, which is below T=2000 K?

3. Could the transition zone be at criticality against the phase transition to superionic water? This idea would conform with the proposal that the region in question is not homogenous.

REFERENCES

Condensed Matter Physics

[D1] Mills R et al. Spectroscopic and NMR identification of novel hybrid ions in fractional quantum energy states formed by an exothermic reaction of atomic hydrogen with certain catalysts, 2003. Available at: http://www.blacklightpower.com/techpapers.html.

[D2] Prakapenka VB et al. Structure and properties of two superionic ice phases. *Nature Physics*, 17(11):1–6, 2021. Available at: https://www.researchgate.net/publication/355212207_Structure_and_properties_of_two_superionic_ice_phases.

Cosmology and Astro-Physics

[E1] Nottale L Da Rocha D. Gravitational Structure Formation in Scale Relativity, 2003. Available at: http://arxiv.org/abs/astro-ph/0310036.

[E2] Wittem E. Searching for a Black Hole in the Outer Solar System, 2020.Available at: https://arxiv.org/abs/2004.14192.

[E3] Schaber R et al. The Resurfacing History of Venus, 1997. Available at: https://www.researchgate.net/publication/234304451_The_Resurfacing_History_of_Venus.

[E4] Romeo I and Turcotte DL. Resurfacing on Venus . *Planetary and Space Science*, 58(10):1374–1380, 2010. Available at: https://doi.org/10.1016/j.pss.2010.05.022.

Physics of Earth

[F1] Dong J et al. Constraining the Volume of Earth's Early Oceans With a Temperature-Dependent Mantle Water Storage Capacity Model. *AGU Advances*, 2(1), 2021. Available at: https://doi.org/10.1029/2020AV000323.

[F2] Giuliani A et al. Perturbation of the deep-Earth carbon cycle in response to the Cambrian Explosion. *Science Advances*, 8(9), 2022. Available at: https://www.science.org/doi/10.1126/sciadv.abj1325.

Biology

[I1] The Fourth Phase of Water: Dr. Gerald Pollack at TEDxGuelphU, 2014. Available at: https://www.youtube.com/watch?v=i-T7tCMUDXU.

[I2] Drake H et al. Anaerobic consortia of fungi and sulfate reducing bacteria in deep granite fractures. *Nature Communications*, 8(55), 2017. Available at: https://www.nature.com/articles/s41467-017-00094-6.

[I3] He T et al. Possible links between extreme oxygen perturbations and the Cambrian radiation of animals. *Nature Geoscience*, 12:468–474, 2019. Available at: https://www.nature.com/articles/s41561-019-0357-z.

[I4] Klatt JM et al. Possible link between Earth's rotation rate and oxygenation. *Nature Geoscience*, 14:564–570, 2021. Available at: https://www.nature.com/articles/s41561-021-00784-3.

[I5] Zhao Q Pollack GH, Figueroa X. Molecules, water, and radiant energy: new clues for the origin of life. *Int J Mol Sci*, 10:1419–1429, 2009. Available at: http://tinyurl.com/ntkfhlc.

[I6] Pollack GH Zheng J-M. Long-range forces extending from polymer-gel surfaces. *Phys Rev E*, 68:031408–, 2003. Available at: http://tinyurl.com/ntkfhlc.

Books related to TGD

[K1] Pitkänen M. Expanding Earth Model and Pre-Cambrian Evolution of Continents, Climate, and Life. In *Genes and Memes: Part II*. Available at: https:/tgdtheory.fi/pdfpool/expearth.pdf, 2006.

[K2] Pitkänen M. Homeopathy in Many-Sheeted Space-Time. In *Bio-Systems as Conscious Holograms*. Available at: https:/tgdtheory.fi/pdfpool/homeoc.pdf, 2006.

[K3] Pitkänen M. Life and Death, and Consciousness. In *TGD based view about living matter and remote mental interactions: Part I*. Available at: https:/tgdtheory.fi/pdfpool/lifedeath.pdf, 2019.

Articles about TGD

[L1] Pitkänen M. Are dark photons behind biophotons? *Journal of Non-Locality*, 2(1), 2013. See also https:/tgdtheory.fi/pdfpool/biophotonslian.pdf.

[L2] Pitkänen M. Maintenance problem for Earth's magnetic field. Available at: https:/tgdtheory.fi/public_html/articles/Bmaintenance.pdf., 2015.

[L3] Pitkänen M. About Physical Representations of Genetic Code in Terms of Dark Nuclear Strings. Available at: https:/tgdtheory.fi/public_html/articles/genecodemodels.pdf., 2016.

[L4] Pitkänen M. Hydrinos again. Available at: https:/tgdtheory.fi/public_html/articles/Millsagain.pdf., 2016.

[L5] Pitkänen M. Does valence bond theory relate to the hierarchy of Planck constants? Available at: https:/tgdtheory.fi/public_html/articles/valenceheff.pdf., 2017.

[L6] Pitkänen M. Philosophy of Adelic Physics. In *Trends and Mathematical Methods in Interdisciplinary Mathematical Sciences*, pages 241–319. Springer.Available at: https://link.springer.com/chapter/10.1007/978-3-319-55612-3_11, 2017.

[L7] Pitkänen M. Philosophy of Adelic Physics. Available at: https:/tgdtheory.fi/public_html/articles/adelephysics.pdf., 2017.

[L8] Pitkänen M. Expanding Earth hypothesis, Platonic solids, and plate tectonics as a symplectic flow. Available at: https:/tgdtheory.fi/public_html/articles/platoplate.pdf., 2018.

[L9] Pitkänen M. Expanding Earth Model and Pre-Cambrian Evolution of Continents, Climate, and Life. Available at: https:/tgdtheory.fi/public_html/articles/expearth.pdf., 2018.

[L10] Pitkänen M. Maxwell's lever rule and expansion of water in freezing: two poorly understood phenomena. Available at: https:/tgdtheory.fi/public_html/articles/leverule.pdf., 2018.

[L11] Pitkänen M. An overall view about models of genetic code and bio-harmony. Available at: https:/tgdtheory.fi/public_html/articles/gcharm.pdf., 2019.

[L12] Pitkänen M. Cosmic string model for the formation of galaxies and stars. Available at: https:/tgdtheory.fi/public_html/articles/galaxystars.pdf., 2019.

[L13] Pitkänen M. Earhquakes and volcanic eruptions as macroscopic quantum jumps in zero energy ontology. Available at: https:/tgdtheory.fi/public_html/articles/earthquakes.pdf., 2019.

[L14] Pitkänen M. Some comments related to Zero Energy Ontology (ZEO). Available at: https:/tgdtheory.fi/public_html/articles/zeoquestions.pdf., 2019.

[L15] Pitkänen M. A critical re-examination of $M^8 - H$ duality hypothesis: part I. Available at: https:/tgdtheory.fi/public_html/articles/M8H1.pdf., 2020.

[L16] Pitkänen M. A critical re-examination of $M^8 - H$ duality hypothesis: part II. Available at: https:/tgdtheory.fi/public_html/articles/M8H2.pdf., 2020.

[L17] Pitkänen M. Comparing the Berry phase model of super-conductivity with the TGD based model. https://tgdtheory.fi/public_html/articles/SCBerryTGD.pdf., 2021.

[L18] Pitkänen M. Negentropy Maximization Principle and Second Law. Available at: https://tgdtheory.fi/public_html/articles/nmpsecondlaw.pdf., 2021.

[L19] Pitkänen M. TGD and Condensed Matter. https://tgdtheory.fi/public_html/articles/TGDcondmatshort.pdf., 2021.

[L20] Pitkänen M. TGD as it is towards the end of 2021. https://tgdtheory.fi/public_html/articles/TGD2021.pdf., 2021.

[L21] Pitkänen M. TGD view of the engine powering jets from active galactic nuclei. https://tgdtheory.fi/public_html/articles/galjets.pdf., 2021.

[L22] Pitkänen M. Updated version of Expanding Earth model. https://tgdtheory.fi/public_html/articles/expearth2021.pdf., 2021.

[L23] Pitkänen M and Rastmanesh R. DNA and Time Reversal. Available at: https://tgdtheory.fi/public_html/articles/DNAtimereversal., 2020.

[L24] Pitkänen M and Rastmanesh R. Homeostasis as self-organized quantum criticality. Available at: https:/tgdtheory.fi/public_html/articles/SP.pdf., 2020.

[L25] Pitkänen M and Rastmanesh R. The based view about dark matter at the level of molecular biology. Available at: https:/tgdtheory.fi/public_html/articles/darkchemi.pdf., 2020.