About the TGD based models for Cambrian Explosion and the formation of planets and Moon

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Abstract

The TGD based cosmology predicts that the cosmic expansion occurs as rapid phase transitions, increasing the thickness of the monopole flux tubes and liberating energy.

One application is the Expanding Earth (EE) hypothesis stating that the Cambrian Explosion about half billion years ago was induced by a relatively rapid increase of Earth radius by factor 2: I call this event EE event . The details of the energetics of this transition remain far from well-understood. The same problem appears in the model for the formation of the Moon as a transition in which a surface layer of the Earth was thrown out to form the Moon by gravitational condensation. Where did the energy needed to compensate for the decrease of the gravitational binding energy in these explosive transitions come from? The proposal is that the TGD variant of "cold fusion" provided the energy so that nuclear physics would have played a key role in the geological evolution.

Zero energy ontology (ZEO) suggests that the two events correspond to subsequent "big" state function reductions (BSFRs) in astrophysical scales changing the arrow of geometric time on a scale of billions of years.

The earlier versions of the model made some unnecessarily strong assumptions, in particular the analogy with the recent Mars. A more precise formulation of the analogy allows to get rid of wrong predictions such as absence of oceans, plate tectonics, and continents before the EE event. During recent years it has become clear that superionic phases are possible in the mantle and core and their possible role is discussed from the TGD point of view.

1 Introduction

TGD based cosmology [L14] predicts that the cosmic expansion occurs as a sequence of rapid phase transitions, increasing the thickness of the monopole flux tubes and liberating energy as the string tension is reduced.

One application is Expanding Earth hypothesis [L4, L6, L9], which states that Cambrian Explosion (CE) about half billion years ago was induced by a relatively rapid increase of Earth radius by factor 2. The details of the energetics of this transition is still far from well-understood although I have considered several options [L22]. The same problem appears in the model for the formation of the Moon [L15] as a transition in which a surface layer of the Earth was thrown out to form Moon by gravitational condensation.

Where did the energy needed to compensate for the decrease of the gravitational binding energy in these explosive transitions come from? A rough estimate for the gravitational binding energy of a proton at the surface of the Earth is about 1 eV. Gravitational energy is not the only energy involved so that the estimates involving only gravitational energy are very uncertain. What seems clear is that the needed energy cannot be electromagnetic.

I have already earlier proposed that the transformations of the so-called dark nuclei to ordinary nuclei and liberating almost all ordinary nuclear binding energy could explain "cold fusion" [L18]. The TGD counterpart of "cold fusion" could also provide the energy needed to compensate for the reduction of the gravitational binding energy in the both transition. In this article also an attempt to fuse the TGD views about the formation of the Moon and Expanding Earth hypothesis (EE) explaining CE to a unified narrative about geological and biological evolution is made by using various guidelines. The observation that angular momentum conservation predicts for both models the same result for the rotation velocity of the Earth before CE and also before the formation of the Moon, plays a key role in the model.

Zero energy ontology (ZEO) suggests that the two events correspond to subsequent "big" state function reductions (BSFRs) in astrophysical scales changing the arrow of geometric time on a scale of billions of years.

The original versions of both models made some un-necessarily strong assumptions and comparison with empirical data allows us to loosen them.

1. The recent Mars with radius near $R_E/2$ was taken as an analog model for the evolution of the Earth before CE. A more precise assumption takes into account that the formation of the moons of Mars took place about much later than for the Earth.

   Therefore the analogy applies only to the early geological evolution of the Earth after the formation of the Moon. This allows us to circumvent conflicts with the empirical data. The existence of the oceans, continents, and plate tectonics, not present in the recent Mars, does not lead to a conflict.

2. Angular momentum conservation was applied originally by assuming that angular momentum transfer from Moon to Earth was instantaneous so that the rotation velocity Ω of the Earth was 4 times the recent rotation velocity before CE. A more realistic assumption is that the transfer was gradual. One can however assume that the radius was roughly $R_E/2$ before the EE event. This allows to avoid conflicts with the empirical determinations of the rotation velocity Ω.

3. The so-called Great Uniformity, which looks mysterious in the standard physics framework, provides very direct evidence for the occurrence of the second BSFR leading to the doubling of the Earth radius. Also the very large increase of oceans conforms with the TGD view of the EE event. The Snowball Earth hypothesis used to explain the Great Uniformity is not needed.

4. The proposal that the formation of the Moon and EE event were induced by explosions associated with the core allows us to understand why the radius of the earth was reduced in the formation of the Moon and increased in the EE event. The identification of these events as "cold fusion" transforming dark nuclei to ordinary ones would have liberated a huge energy allowing to compensate for the reduction of the gravitational binding energy.

5. Zero energy ontology (ZEO) allows us to interpret the period before CE as a period with a reversed arrow of the geometric time. The paradoxical looking prediction is that the Moon was formed in the geometric future of the recent Earth! This forces a careful reconsideration of the empirical data obtained by various dating methods. Since the dating methods do not give information about the time associated with say systems with scale much larger than the Earth it seems that they are not sensitive to the arrow of the geometric time. If this is really true it means that ZEO not only solves the measurement problem but correctly predicts a change of the geometric arrow of time in the scale of billions of years.

6. During recent years it has become clear that the so called superionic phases in the mantle and core could be central for the understanding of geology. Some of the superionic phases could also have dark variants, which raises the question whether life in some exotic form is or could have existed also in the Earth's mantle and core.

7. The role of superionic phases already found to play a potential role in the interior physics of the Earth are discussed from the TGD point of view.

2 A TGD based model for the expansion/explosion of Earth

2.1 A general view of the the transition leading to expansion and explosion

4 values of the effective Planck constant h_{eff} labelling the dark phases at the magnetic body (MB) in question are involved: the huge gravitational Planck constants $\hbar_{gr} = GMm/\beta_0$ for the Sun ($M = M_S$) and the Earth ($M = M_E$), the value of $h_{cold} \sim 10^3 h$ assigned with dark protons in the TGD based model of "cold fusion" [L18] and the ordinary Planck constant h. Note that $\hbar_{gr} \sim 10^{14}$ is a rough estimate for the Earth-proton pair: it implies that 10 Hz EEG photon corresponds to 10 eV UV photon.

The most general expectation is that the phase transition sequence $h_{gr,Sun} \to h_{gr,E} \to h_{cold} \to h$ took place as the Earth was formed after a surface layer of the Sun or a region of it was thrown out from the Sun in an explosion [L10, L11]. The model for the formation of the Moon [L15] proposes that the explosion throwing out a surface layer of the Earth led to the formation of the Moon.

1. The first step of the transition would be the transfer of protons and nuclei from the gravitational MB of the Sun to that of the Earth.

2. The next step would be the transfer of dark matter from the gravitational MB of the Earth to dark nuclei associated with $h_{gr,E} \to h_{cold} \sim 10^3\hbar$.

   The size scale of the dark proton is of the order of electron Compton length and the counterpart of the dark atom has the same size scale for the ordinary Planck constant. 1 eV energy is the gravitational energy scale and the binding scale of cold fusion is 10 keV.

3. Could dark nuclear fusion as "cold fusion" associated with the transition $h_{cold} \to h$ provide the energy for the explosion? The transformation of dark nuclei identified as dark proton sequences to ordinary nuclei liberates almost all nuclear binding energy and is the most energetic step in the sequence.

4. Does the dark matter at the gravitational MB consist of a) gravitationally dark protons or b) dark nuclei with $h_{eff} = h_{cold}$? For option a) the dropping from the gravitational MB could be induced by the drop of the temperature below a critical value corresponding to gravitational binding energy for the dark nuclei formed in the process. This would mean that thermal agitation drives the protons to the gravitational MB. One can speak of dark gravitational collapse. The transformation of dark nuclei to ordinary nuclei by "cold fusion" would take place later. It is difficult to imagine any energetices for option b).

5. The dark nuclear binding energy at the monopole flux tubes is proposed to stabilize dark DNA codons against the spontaneous reduction of h_{eff} [L20]. The transfer of protons to monopole flux tubes induced generation of negatively charged exclusion zones (EZs) appearing in Pollack effect [I3, L1, I5, I4] [L1, L13]. The associated long length scale electric fields would serve as signature for stable $h_{eff} > h$ phases and they appear also in "cold fusion" [L18].

   The same stabilization mechanism of $h_{eff} > h$ phases appears in various scales such as cell membrane, brain, body and even the Earth. The electric field of Earth could be associated with the EZ associated with the Earth and provide an estimate for the total dark charge at the gravitational MB of the Earth.

6. During the periods preceding the explosion/expansion, the number of dark protons at the gravitational MB would have been considerably higher than after the transition and this suggests that the Earth had considerably larger negative charge and therefore also a stronger electric field.

2.2 Some order of magnitude estimates

To build a quantitative picture, some order of magnitude estimates are required.

1. The gravitational binding energy $E_{gr,S}$ per nucleon at the gravitational MB of the Sun is by a factor $M_S/M_E \times R_E/R_S \sim 3 \times 10^5$ larger than the gravitational binding energy $E_{gr,E}$ per nucleon at the gravitational field of the Earth at the surface of Earth. For protons the latter is of order 1 eV. This gives $E_{gr,S} \simeq .3$ MeV to be compared with the mass of electrons equal to .5 MeV. At the surface of Earth, the gravitational binding energy associated with the gravitational potential of the Sun is $E_{gr,S} \simeq 3$ keV.

2. In the case of the Sun, the Maxwellian estimate of the average solar magnetic field at the distance of the Earth is 5 nanotesla. This estimate might be wrong at the level of the flux tubes if the monopole flux tubes of the gravitational MB forming loops have constant thickness (the flux is conserved and quantized).

If the monopole flux tubes thicken with distance, the average field at the flux tubes can weaken like a dipole field. The monopole flux tubes from the Sun need not have a spherically symmetric distribution but could connect the Sun to various planets instead and have a constant field strength.

The distance of the Earth from the Sun is approximately 216 solar radii. The ratio of dipole magnetic field strengths at the Earth and solar surface would be from this about $10-7$ and would require field strength about $B_S = .05$ Tesla at the surface of the Sun. The magnetic field $B_E \simeq 5 \times 10^{-5}$ Tesla of the Earth is 3 orders of magnitude weaker. The monopole part B_{end} of B_E is estimated to be $2/5B_E$. The ratio $B_{end}/B_S \simeq .4 \times 10^{-3}$ and happens to be rather near to the estimate $\beta_{0,S}/\beta_{0,E} \simeq 2^{-11}$ for the ratio of the velocity parameters appearing in $\hbar_{gr,S}$ and $\hbar_{gr,S}$.

The strength of the solar magnetic field varies in a wide range. During the quiet periods of the solar activity it is $(.1-.2)\times 10^{-5}$ Tesla and rather near to the magnitude as the monopole part B_{end} of the Earth's magnetic field: could the flux tubes of B_{end} arrive from the Sun? During the active periods the strength is .2-.3 Tesla and even .6 Tesla to be compared with the above estimate $B_S = .05$ Tesla.

2.3 Is "cold fusion" as dark fusion the basic mechanism

Could a rapid dark fusion to ordinary nuclei as a long length scale phase transition induce the explosion by liberating a large energy as nuclear binding energy? Or was this process a local continual process?

2.4 The TGD based models for the Sun, and formation of planets and Moon as guidelines?

Here the TGD based models for the Sun and and for the formation of planets and even of the Moon in mini big bangs [L10, L11, L22] provide guidelines for the speculations.

1. In the standard stellar model, a supernova is believed to occur as the nuclear fusion at the core stops and pressure is not able to prevent gravitational collapse and this induced explosion, throwing out the outer layer.

   In the TGD based model of the star, the decay of M_{89} nuclei to ordinary M_{107} nuclei produces solar radiation and solar wind. At the surface of the Sun, dark nuclei are formed and in the gravitational field of the Sun they drift to lower depths [L17].

   The dark nuclei transform to ordinary nuclei. Is the process local and continually occurring or does it occur as phase transitions throwing parts of the surface layers or even an entire surface layer out.

2. The TGD view of the formation of planets assumes that planets were formed as a surface layer of the Sun or part of it exploded and gravitationally condensed to form the planet [L10, L11]. What could have caused this kind of explosion?

   Where did the energy needed to compensate for the reduction of the gravitational binding energy come from? Was this caused by dark fusion as the TGD counterpart of "cold fusion" transforming dark nuclei at the surface of the Sun to ordinary ones? If this was the case, the gravitational collapse would not have played a significant role in the formation of planets.

   Was a considerable fraction of dark nuclei with $h_{eff} \sim 10^3 h \leq\leq h_{gr}$ stable against decay to dark protons and did it form part of the mass of the planet. Was h_{eff} stabilized by the dark nuclear binding energy? What fraction of dark nuclei was transformed to ordinary ones?

3. Did these dark nuclei transform later to ordinary nuclei by the same mechanism as in "cold fusion" [L2, L18]? What induced the quantum criticality against the transformation to ordinary nuclei?

   The energy (or free energy) of the state consisting of the ordinary nuclei became lower than that consisting of dark nuclei. The gravitational binding energy indeed increased in the

reduction of h_{eff}: was a dark variant of gravitational collapse involved? Was the temperature reduced below a critical value so that the thermal energy could not kick ordinary particles to $h_{eff} > h$ phase anymore. Did this lead to an explosion in a region of the core throwing out a surface layer of the Earth creating the Moon via gravitational condensation? A similar phase transition could have induced Cambrian Explosion as a doubling of the radius of the Earth.

3 Is a TGD based unified view of the geological and biological evolution of the Earth possible?

How to unify the models for the formation of the Earth, Moon and Expanding Earth hypothesis hypothesis (EE) as an explanation of Cambrian Explosion (CE) to a single unified narrative about the evolution of life at the Earth. Could zero energy ontology (ZEO), predicting that in BSFRs the arrow of time changes, come in rescue. The formation of Moon and CE are excellent candidates for two subsequent BSFRs.

3.1 Questions

There are several questions creating worries about the internal consistency of the TGD view of the formation of Moon and EE.

1. Did Earth have oceans and continents before the CE? The radius of Earth should have been 1/2 of its recent radius before CE. Does this make sense?

2. Angular momentum conservation predicts that the duration of day was 6 hours before CE. Can this prediction be consistent with empiral facts?

3. Angular momentum conservation applies also to the formation of the Moon and predicts that the duration of day have been 6 hours before this event. How can this be consisted with the same prediction in the case of CE?

4. The large water volumes in the iterior of the Earth proposed in TGD based model are not consistent with what is known about the crust of the recent Earth. Could the TGD based physics allow their presence?

3.2 Objections against the TGD based vision

EE hypothesis states that the radius of the Earth increased by factor 2 in CE. Before it it would have be roughly the same as that of Mars. Mars has radius $R_E/2$ and has two moons. Mars has no oceans and no continents. Was the Earth like Mars before CE? Did water go underground after its moons were formed and life is involving there? How can this be consistent with empirical facts.

The proposal has problems.

1. The original form of hypothesis stated that there were no oceans before CE and life developed in underground oceans. There are excellent justifications for this hypothesis (absence of cosmic rays and meteor bombardment, higher temperature in the interior,...). Also Mars, having essentially radius equal to one half of the radius as Earth and two moons, has no Moons, tectonics, nor continents. This suggests that same is true also for the Earth before EE.

   It is known that the EE event increased the amount of water in the seas dramatically. It is not necessary to assume that there were no oceans, no continents, and no tectonics before the EE event. This seems to be in confict with the empirical evidence. The analogy with Mars is however very attractive. Could there be a way to avoid the paradox.

2. Underground water reservoirs as regions where the life evolved are necessary in the TGD picture. Standard physics does not however allow these. Could Pollack phase for water make large reservoirs possible in TGD. Can we think that dark (large h_{eff}) water (Pollack phase)

underground was formed in the formation of Moon as an explosion that threw off the surface layer?

Pollack effect indeed changes the arrow of time. Did the Pollack phase of water burst on the surface in CE and form the recent oceans.

3. One can also criticize the idea that the expansion of the Earth radius by factor 2 occurred very rapidly. An alternative view is that the radius of the Earth gradually returned to its original value after the formation of the Moon so that expansion period would have lasted from the formation of the Moon to CE. For this option it is however not easy to understand why the burst of water and underground life form to the surface was such a rapid an event.

3.3 Some guidelines

There are several guidelines helping in an attempt to costruct a TGD inspired narrative about the geological and biological evolution of the Earth.

3.4 The hierarchy of effective Planck constants

To begin with, one must clarify how TGD based quantum ontology differs from the standard one. Here only the hierarchy of Planck constants implied by the number theoretic vision is discussed. Zero energy ontology [K1] will not be discussed here.

1. The quantum ontology of TGD predicts the existence of a hierarchy of phases of the ordinary matter labelled by effective Planck constant $h_{eff} = nh_0$, where ordinary Planck constant is $h = n_0 h_0$, where n_0 is proposed to have the value $n_0 = (7!)^2$ and is estimated from the ratio of the CP_2 length scale $R \sim 10^4 l_P$ to Planck scale l_P. The larger the value of h_{eff} the longer the Compton length of the particles. These phases behave like dark matter but do not correspond to galactic dark matter which in the TGD framework is more analogous to dark energy.

2. One can also assign to long range classical fields gravitational *resp.* electric fields gravitational $\hbar_{gr} = GMm/\beta_0$ [E1] *resp.* electric Planck constant $\hbar_{em} = Qqe^2/\beta_0$ [L8]. M and m denote masses and Q and q charges and the conditions $\hbar_{gr}/h > 1$ $\hbar_{em}/h > 1$ must hold true. If m (a) corresponds to elementary particle mass (charge), M (Q) must be large enough. $\beta_0 = v_0/c < 1$ is a velocity parameter. For the Sun one has $\beta_0 \simeq 1^{-11}$ and for the Earth $\beta_0 \simeq 1$.

3. The phase transition increasing the value of h to h_{gr} (h_{em}) occurs when the product of masses (charges) is so large that perturbation theory ceases to converge. One could say that Mother Nature loves her theoreticians.

3.4.1 The TGD based model for the formation of the Moon

The Theia hypothesis (see this) as a model for the formation of Moon is not consistent with the fact that the materials in the Moon and Earth are very similar. In TGD, this leads to the hypothesis that the Moon was formed in an explosion of the Earth analogous to supernova explosion [L15].

In which part of the Earth, the transformation of dark nuclei to ordinary ones took place? Was it mantle, outer core or inner inner core? Outer core is the most plausible option below the already existing mantle is the only option. The layer of thickness about $R_E/8$ containing crust and part of the core was thrown away, which explains why the Earth surface was covered by magma immediately after the formation of the Moon.

How to understand the existence of Fe and Ni plus small fractions of other nuclei in the core? Does the standard explanation as sinking downwards apply? Or were the dark variants of the heavy nuclei formed in dark fusion and transformed to ordinary nuclei in a very rapid "cold fusion" [L18]. Or could they have formed already at the solar surface in the layer thrown that was condensed to form the Earth?

3.4.2 Conservation of angular momentum as a guideline

Conservation of total angular momentum for the Moon-Earth system leads to an estimate of 6 hr for the length of the day before the Moon was born. The EE hypothesis predicts that the same length of the day before CE.

Conservation of angular momentum in the Moon-Earth system. The Moon's L is about 4 times the Earth's S. A lot of angular momentum would have been lost from the surface layer. The Earth's angular momentum would have decreased by a factor of 1/4. It seems that the day had to lengthen accordingly because I did not change much. The day would have lengthened by a factor 4.

What happened to the radius R of Earth when the Moon was formed? The argument based on angular momentum conservation assumes that the radius before the formationof the Moon was the recent radius R_E. If the radius of the Earth was R_E before the explosion, a reduction by $\Delta R \sim R/8$ explains the mass of the Moon [L15]. This suggests the ejection of the Moon a supernova-like event involving gravitational collapse in which the radius was reduced by factor 1/2.

Was CE induced by a time reversal at some level of the field body! Note that ZEO predicts that there is no information as classical signals from from the time reversed period before CE and information would be only theoretical. It is however possible to get information about this period at the level of the ordinary matter by using for instance various dating methods.

3.4.3 Could the structure of Earth give some guidelines?

Earth has a core, inner core and inner inner core. Fe and Ni are their dominating elements. Could the occurrence of two explosions caused by "cold fusion" and producing Moon and CE have led to the emergence of the inner core and inner inner core? One can imagine 2 alternative models for these two explosions.

1. The first option corresponds to a continually occurring "cold fusion" as a counterpart of ordinary fusion occurring in the core, inner core, or "inner inner core" produced ordinary nuclei in the core. Eventually the dark fusion ceased since lighter dark nuclei, in particular dark protons, serving as a fuel were depleted. In this situation most nuclei were stable nuclei such as Fe and Ni. This induced the planetary analog of supernova explosion. Gravitational collapse would have occurred as the pressure was reduced in the core and threw out a surface layer of the core inducing the expansion. The gravitational energy liberated in the collapse would have provided the energy needed by the explosion.

   The continually occurring dark fusion would have produced a lot of energy. Is the continuous energy production consistent with what is known about the Earth's thermal history? Is there any way to test whether the size of the core region was reduced.

2. The second option corresponds to "cold fusion" as a collective and relatively fast transformation of dark nuclei to ordinary nuclei liberated ordinary nuclear binding energy and induced the explosion. This explosion would have produced a considerable fraction of heavy elements in the core of the Earth.

   Interestingly, the transformation of gravitationally dark nuclei at the gravitational MB of the Sun to dark nuclei would have meant a considerable reduction of the average distance of the nuclei from the center of the Sun so that in this sense the effective size of the Sun would have reduced. Therefore there is a rough analogy with the standard view of gravitational collapse.

Obviously, several open questions remain even if one assumes that the sequence of 4 transitions implies that the rapid expansion is associated with a "cold" fusion as collective phase transition.

3.5 A ZEO based vision about the formation of the Moon and of Cambrian Explosion

In the sequel it is proposed that zero energy ontology (ZEO) could play a key role in the understanding of both geological and biological evolution of the Earth.

3.5.1 The overall ZEO based view of the period between the formation of the Moon and Cambrian Explosion

It is good to start by stating what the zero energy ontology (ZEO) based view integrating the views about the formation of the Moon and EE event as giving rise to CE.

1. Two "big" state function reductions (BSFRs) involving a time reversal took place. First BSFR led to the formation of the Moon and second BSFR to CE. One could say that field body of the Earth experienced a reincarnation at the level of conscious experience.

2. The birth of the moon was analogous to a supernova involving gravitational collapse and explosion throwing out a surface layer, which gravitationally condensed to form the Moon. Just before the birth of the Moon, the radius of the Earth is assumed to be $R_- = R_E$ in the estimate assuming angular momentum conservation. Angular angular momentum conservation for $R_- = R_E$ requires that rotational angular momentum $S_- \propto MR^2\Omega$ just before the formation of the Moon $S_- = 4S_E$, that is 4 times its recent value. This is satisfied for $\Omega_- = \Omega_+ = 4\Omega_E$ implying that the length of the day was 6 hr.

3. The most realistic look model for the classical evolution, to be distinguished from BSFR [L5], after that involved the gradual transfer of the spin $S_- \propto R_E^2\Omega_- = 4S_E$ to the Moon. $R = R_E$ and $\Omega_- = 4\Omega$ decreased.

   In the simplest version of the EE hypothesis, R_E decreases to $R_E/2$ and Ω remains constant during this period. This evolution could be interpreted as a reaction to the explosion throwing out the surface layer and inducing the decrease of R_E as a recoil. After that the second BSFR inducing CE happened and according to the EE hypothesis R_E grew rather rapidly from $R_{E,min} \simeq R_E/2$ to R_E. Also Ω decreased.

   Here empirical data provides information.

   Gemini: Certain sedimentary rocks (sandstones) preserve daily and monthly tidal layers and serve as tidal rhythmites. By counting these bands, geologists have confirmed that in the distant past each day was shorter. The earliest reliable determination is around 2.5 billions ago and and gave for the length of the day the estimate 18 hours. If Moon was formed for $T = 5$ billion years ago, the length of the day would have increased during $T/2 \sim 2.5$ billion years by $3T/4$ and during the 2.5 billion years by $T/4$ to is its recent value $T = 24$ hr.

   Fossilized corals from the Devonian period ($\sim$ 400 million years ago) show approximately 400 daily growth rings per year, confirming that days were only about 22 hours long at that time.

   TGD: This supports the option that the transfer of the angular momentum to the Moon meant a gradual decrease of Ω whereas the radius of the Earth remained $R = R_E/2$ and grew rather rapidly in EE.

4. The second BSFR corresponds to an EE event inducing the CE. Now the gravitational collapse or its dark analog, perhaps occurring for the inner core, could have reduced its radius but induced as a recoil effect an explosion increasing the size of the Earth.

   Angular momentum conservation applied to EE event requires that the radius before the CE was $R = R_E/2$ and $\Omega = 4\Omega_E$, just as in the previous case. Angular momentum conservation in the formation of the Moon implies $R_- = R_E$ and was reduced to $R_+ = R_E/2$. The BSFR associated with EE event would have replaced the Bohr orbit-like space-time surface with a new one for which $R = R_E/2$ grew rather rapidly to R_E. The findings of Minev et al [L5] [L5] conform with this interpretation.

   The EE event would have reduced the average density of the Earth by factor 1/8 in a rather short time and the model for based on "cold" fusion of dark nuclei in the inner core to ordinary nuclei, mostly fermions forming a solid state, should provided the energy needed by the explosion to compensate for the reduction of the gravitational binding energy.

3.5.2 More precise view of ZEO

The classical time evolution interpolates between the initial and final 3-D quantum states by SSFRs after BSFR. At the field body, controlling the dynamics in short stalces, there would be two classical time evolutions corresponding to two different arrows of time. Both time evolutions would have signatures at the microscopic level. This could help to explain the conflicts with empirical facts as apparent conflicts.

1. Suppose that the time evolution inside CD assignable to the field body and controlling the time evolution at the level of matter, corresponds to a gradual increase of the geometric time assignable to the subjective times and identifiable as Lorentz invariant proper time assignable to the passive boundary of CD from some rather small value which then increases.

2. The CD increases in size during the sequences of SSFRs and either boundary of the CD is passive in the sense that 3-D states defining the data of holography are not affected in SSFRs. Concerning CD, there are two options. Also the passive boundary of CD remains invariant in SSFRs or the entire CD experiences scaling in all SSFRs [L12]. It is better to leave open the question which of these two extremes is nearer to reality.

3. Note that the time assignable to larger astrophysical structures than the Earth or its field body is also needed. It would define the time that could be said to be objective. There are also times assignable to smaller structures that the field body and in atomic scales the arrow of time changes continually since the duration between BSFRs is much shorter.

To make progress one must understand what one really means with the geometric time assignable to a given CD.

1. The interpretation of CD as a perceptive field of a larger entity (larger CD) can be used as a guideline. The moduli degrees of freedom for the CD form a finite-dimensional space and this suggests that there is a wave function SFRs inducing delocalization in this moduli space [L12]. At the classical level, CDs can experience Poincare transformations and scalings in SFRs. Even a temporal shift could take place in SFRs in the time direction determined by the arrow of time of the larger CD. If this movement in time direction is slower than the rate for the increase of the size of the larger CD it does not lead out from it. The CD as a target of attention of the larger CD stays inside the larger CD.

2. It seems however that what matters are scalings. The passive boundary of CD should remain invariant or at least transform in a very simple manner in the SFRS. This is the case if only scalings of the passive boundary are allowed for SSFRs. This option will be discussed in the following.

   There are several options for the identification of the geometric time. One can consider the situation at the level of the hierarchy of CDs. The geometric time could correspond to the geometric time defined by the statistically increasing distance $2T$ between the tips of the CD assignable to the level of the field body for which the two BSFRs occur. This geometric time could correspond to the geometric time, which correlates with the clock time determined by the dynamics of distant stars. One can use instead of $2T$ also the M^4 time coordinate for the rest system of CD. Also the center of mass (cm) of a CD defines geometric time. Also the M^4 time coordinate for the tip of the CD defines a geometric time. T

One can also consider the situation at the level of the hierarchy of space-time sheets associated with a given CD.

1. The geometric time could correspond to the geometric time assignable to the SSFRs for a conscious system assignable to the field body. The loci of non-determinism for the space-time surface as an analog of Bohr orbit would define the possible time values and this time would correspond to the most recent SSFR. There is an entire hierarchy of geometric times corresponding and at the microscopic level the durations of periods with a fixed arrow of geometric time are short since BSFRs correspond to ordinary SFRs.

2. The geometric time coordinate could be identified as the light-cone proper time $a_\pm$ of the passive tip of the CD (at which quantum states in 3-D sense are not changed in SSFRs (Zeno effect)) assignable to a give locus of non-determinism in a given SSFR. One can assign to it ordinary linear M^4 time $t_\pm$ in the rest system of the CD, identifiable as the minimum of $t_\pm$ at $a_\pm = constant$ hyperboloid. Minkowski time $t_\pm$ is also natural from the number theoretic perspective since it corresponds to a real part of octonion defining M^8 coordinate [L21, L19].

3. $a_\pm$ has a value range $(0, 2T)$, where T corresponds to the size scale of the CD. In SSFRs, $a_\pm$ ($t_\pm$) increases in a statistical sense since the size of CD is bound to increase in statistical sense [L12].

4. What happens to $a_\pm$ ($t_\pm$) in BSFRs? The idea that $a_\pm$ ($t_\pm$) increases in a statistical sense looks natural. For $t_\pm \leq T$ just before the BSFR one would have $t_\mp \leq T$ time and t would also increase in BSFRs. The statistical increase of the CD size, characterized by T, guarantees the increase of $a_\pm$ in a statistical sense if there is some favoured large enough minimum value $a_{\pm,min}$ defined as a fixed ratio $r_\pm = a_{\pm,min}/T$.

5. One can argue that for the sequence of SSFRs there is also a maximum value of $a_{\pm,max}$. Could one estimate the value of $a_\pm$? Could $a_\pm$? correspond to a maximal volume for the part of the $a = constant$ hyperboloid contained inside the half cone of the CD? Could this have an interpretation as a maximal information content? The volume of this part of the hyperboloid, expressed in terms of hyperbolic coordinates $r_M/a = r = sinh(t)$, is

$$V_1(a) \equiv \frac{4\pi V(a)}{3} = a^3 \int_0^{t_{max}} sinh^2(t)dt = a^3 \frac{sinh(2t)-t}{2}$$

$$= \frac{1}{2}a^3 \left[\frac{r_M}{a}\sqrt{1+(\frac{r_M}{a})^2} - arsinh(\frac{r_M}{a}) \right] \quad .$$

The value of r_M in the intersection of the hyperboloid with the $t = T$ hyperplane defining the common bottom of the half-cones of the CD is $r_M = T^2 - a^2$.

In the above formula, a reasonable approximation is $cosh(t) \simeq sinh(t) \simeq exp(t)/2$ but is not necessary for an analytic estimate. The arsinh term is logarithmic and can be neglected in a good approximation. This makes it possible to solve the volume maximization condition $dV_1/da = 0$ analytically to give

$$a_\pm = \frac{T}{\sqrt{\sqrt{11}-2}} \simeq \frac{T}{\sqrt{3}} \quad .$$

3.6 ZEO based view of the evolution of the Earth

Consider now what our hypothesis really means assuming the above view of ZEO.

1. The time evolution from the formation of the Moon to the EE event occurs with a reversed arrow of time. The Moon would have been formed in the geometric future of the recent Earth!

2. In the EE event the life bursted to the surface of the Earth and continued with a reversed arrow of time defining "our" arrow of time. The Earth now would have been rather literally created, or more precisely, recreated in CE. The materialistic colleague has good justifications to accuse me of creationism and label me an enemy of science.

One can formulate this more precisely.

1. When we speak of the past of the Earth we usually think of it as something about 5 billion years to the direction of the recent past with respect to time defined by some much larger system, even entire cosmology. Now this time would be about 5 billion years towards our geometric future!

2. How can we make sense of the findings of monocellular fossils dated to have been created about 4 billion years ago? Were they formed in our geometric future at a distance of 4 billion years? Or did they really exist in the geometric past determined by some larger system such as distant stars and having the same arrow of time as we have.

   Can the dating methods tell anything about the geometric time unless they are able to also determine the value of geometric time on a larger scale. Dating methods such as radioactive dating deduce the age from what has happened to the system. This does not tell anything of the direction in which it flows or about the value of the geometric time on a larger scale.

These arguments probably sound crazy in the ears of colleagues, whose view of time realies on the standard ontology but the arguments are only logical implications from the understanding of ZEO that I have managed to develop hitherto. My only defense is that ZEO solves the basic paradox of quantum measurement theory and allows us to understand free will.

Needless to say, this proposal would mean a profound revolution in the world view. The geological and biological evolution of the Earth would demonstrate quantum coherence in astrophysical scales and time reversal in a time scale of 5 billion years.

3.7 What happened in the Earth's interior when CE took place

Consider next what happened in the the Earth's interior in EE inducing CE.

1. It is known that magnetic field almost disappeared before the CE. It is not completely clear to me whether this happened globally or only locally. TGD suggests two models for what happened.

   (a) First model assumes the ro-orientation of monopole magnetic fields explains [L3].

   (b) The second model assumes temporary decomposition to short monopole flux loops by reconnection followed by fusion to long flux tubes looks like a more realistic model [L11]. This model applies also the orientation reversals of the solar magnetic field.

2. The standard theoretical view is that the solid inner core was formed at the time of CE as the magnetic field was formed as currents rotating in the outer core were generated. In ZEO picture this means that this occurred in BSFR returning the original arrow of time.

   The TGD view is that induced currents due to the change of the orientation of MB of the Earth consisting of monopole flux tubes. The rotation of currents around monopole flux tubes generated the Maxwellian non-monopole magnetic fields. The temporary decay of monopole flux tubes to short flux loops in the first BSFR can be considered. This would be the a rather concrete counterpart of biological decay after death.

3. What happened to the temperature and pressure in the inner core? The formation of the solid inner core suggests that the pressure increased. Also temperature could have increased.

   Suppose that the inner core or part of it consist of dark nuclei. Did inner core explode and increase in size. Suppose that dark nuclei transform to ordinary nuclei. How did this affect the pressure. Nuclear binding energy was liberated. This heated the system and increased the pressure. Did this lead to the solidification and explosion. The EE event took away part of this energy.

4. The proposal is that the Pollack water was bursted out like water from a sponge and formed oceans at the surface of the Earth. Did the explosion force the water to the surface. Did the metabolic energy feed as radiation from the interior ceased generating the Pollack effect ceas and did solar radiation replace it.

3.7.1 Comparison between Earth and Mars

There are many similarities between recent Mars and the Earth before CE as predicted by the proposed modle. Mars has two moons. The spin of the Mars dominates over angular momenta of its moons so that radius of Mars would not have changed much in gravitational collaps like event

throwing out the moons. Does an field body assinable with Mars have a reversed arrow of time and will it eventually make a BSFR increasing the radius to its value before the moons were formed?

The surface of Mars looks like a dead planet to us. This conforms with the interpretation of BSFR as death in a universal sense. Also the Earth would have been a dead planet during the period preceding EE.

Mars has no global magnetic field and this could partially explain the absence of life at the surface of Mars. Did the global magnetic field disappear in the formation of the moons? What was the situation in the case of Earth before CE? The magnetic field was present but there was a period before CE during which the magnetic field was very weak, about 10 per cent of the recent strength, and was fluctuating wildly. This can be interpreted in terms of quantum criticality associated with the phase transition leading to the EE event inducing the CE.

TGD based view of decay of magnetic fields as splitting of monopole flux tube pairs to short flux loops and and regeneration as fusion of flux loops to flux tube pairs by reconnection conforms with this picture. This model appleis also to the orientation reversals of the solar magnetic field.

3.8 Could Pollack effect give rise to large underground water reservoirs

In the recent Mars and Earth interior there is water but no macroscopic water reservoirs. The size scales for the water pore are microscopic. There are micropores with size scale below 2 nm (DNA size scale), mesospores with size scale between 2 to 50 nm, micropores with size scale in the range 1-10 μm and mecropores with the size scale in the range 20-100 mum. Note that the scales of pores are basic biological scales.

Could this kill the hypothesis about underground oceans? Could the view of Earth as an analog of Mars during the time reversed period save the situation? The recent Mars would have water reservoirs under its surface and there is indeed some indications for this. There is also indirect evidence support for the existence of water reservoirs below the North Pole of the Earth at the depth of 200 m [I2] [L9].

The problem is to understand how the pores could fuse to form large connected structures as water reservoirs. This topological phase transition has some resemblance to percolation. What comes to mind is Pollack effect, which could make pores exclusion zones (EZs) carrying negative charges. Coulombic repulsion gives a large contribution to the energy and disfavor small pores. The second contribution to the energy related to surface tension.

A very simple model for the energy of a pore with radius R is as

$$E = E_C + E_S \quad , \quad E_C = \frac{Z^2 e^2}{R} \quad , \quad E_S = \sigma R^2 \quad .$$

E_C and E_S denote Coulombic and surface energies. Z denotes the total chare of the pore and σ denotes the surface tension.

What happens when one replaces pore with volume with N pores with volume V/N? Both magma flow and water flow can be assumed to be incompressible. $V \to V/N$ requires

$$R \to \frac{R}{N^{1/3}} \quad .$$

This implies

$$E_S = \sigma R^2 \to N \times \sigma \frac{R}{N^{2/3}} = N^{1/3} E_S \quad .$$

The contribution from the surface tension contribution increases Coulomb repulsion decreases as N increases. For a given R, E is minimum as a function of N for $dE/dR = 0$. This gives

$$N = \sqrt{E_C/E_S} = \sqrt{Ze^2}\sigma R^3 \quad .$$

The minimization of E with respect to R gives

$$R = \sqrt{12}\frac{Z^2 e^2}{\sigma} \quad .$$

The two conditions give $N = 1/sqrt2$ so that a single connected region minimizes the energy.

This simple estimate suggests that the Pollack phase could have arisen when the moon was formed and the crust and and mantle were still in magma state.

1. There was large repulsive Coulomb energy and energy due to the surface tension assignable to the boundary between the Pollack phase of water and crust or mantle environment. The formation of connected regions was energetically favoured. The pore system and magma enviroment behave like incompressible fluid which could have made possible formation of of large connected reservoirs by the fusion of pores.

   Energy minimization favours the formation of few large connected regions over the presence of large number of small connected regions and the magma phase could have made possible the fusion of the pores to few much larger volumes. This would be like mixing of two incompressible fluids.

2. The radiation energy from the Earth's interior would replace solar radiation serving the role of a metabolic currency for Pollack effect. EZs are able to clean inpurities from their interior and this suggests that the second law with a reversed arrow of time holds true at the controlling field body.

3. The exclusion zones (EZs) in the Pollack phase of water are negatively charged. This gives rise to a rather large electric Planck constant h_{em} characterizing also DNA, cell, microtubules, human body, and even the entire Earth. EZs have effectively reversed arrow of time which could be induced from the reversed arrow of time for field body controlling them.

3.9 The possible role of superionic phases in the mantle and core of the Earth

Superionic phases are not only possible but also prevalent in both lower mantle and core, in particular inner core. What is required are extremely high pressures, more than 10^5 times the pressure at the surface of the Earth. In the core and lower mantle these pressures are possible. They are also possible in the very early Earth near the surface. Also superionic ice is possible but requires pressures, which are few million times the pressure at the surface of the Earth. I have discussed the superionic ice from the TGD point of view in [L7, L6].

Could the explosion leading to the formation of the Moon in the analog of gravitational collapse have generated the needed pressure peak in the reduction of the Earth radius by factor 1/2 inducing the formation of various superionic phases even in crust?

Superionic phases involving proton ions could also have dark variants and the Pollack effect creating them could be induced by the radiation at very high temperature. The superionic ice could have transformed to Pollack water forming connected large underground oceans near the surface of the Earth. The formation of superionic ices might be an essential step in the creation of the dark water in the crust and therefore in the evolution of life.

In the following sum basics related to the superionic materials are summarized. These facts and more details are easily found by prompting Google Gemini.

3.9.1 Iron Oxide-Hydroxide ($FeOOH$)

Research has shown that at pressures around 80 GPa and temperatures above (8×10^5 times the pressure at the surface of Earth) 1700 °C conditions typical of the lower mantle hydrogen atoms in FeOOH - become "delocalized". They flow freely like a liquid through the solid oxygen lattice.

These "rivers of protons" suggest that mass and heat transport by convection in the mantle could be magnitudes faster than previously thought, potentially making the solid Earth more "metabolically" active than traditional models suggest. An interesting possibility is that the protons can become dark by Pollack effect transforming $-OH$ to $O^- +$ dark proton at the field body [L16].

3.9.2 Superionic iron hydrids (FeH)

Ultralow velocity zones (ULVZs) in lower mantle can be explaied in terms of superionic iron hydrides FeH in which protons behave like a liquid and negative iron ions form a rigid lattice.

Recent studies (2024 2026) indicate that superionic phases are a primary candidate for explaining ULVZs patches at the core-mantle boundary, where seismic waves slow down significantly. Simulations show that iron hydride (FeH), formed by reactions between subducted water and core

iron, is stable as a superionic phase at the CMB. This phase is extremely dense but has very slow seismic velocities, matching the "squishy" physical attributes observed in ULVZs.

In the TGD framework, one can ask whether the protons are dark. This depends on the energy difference between FeH and Fe^-+dark proton, which should be in the same range as betweem $-OH$ and O^- + dark proton.

3.9.3 Petvoskite ($CaSiO_3$) superions

Davemaonite (petrovskite) is one of the most abundant minerals in the lower mantle. In this case O^{2-} is the ion forming a liquid like state. Vacancies as missing O^{2-} ions in the lattice increases the number of O^{2-} ion. Positive Ca or Si ions defines the stable lattice.

High conductivity in deep mantle finds an explanation. A very high pressure aout 2×10^5 times the pressure at Earth's surface is required by $CaSiO_3$ superionic phase. During Hadean era (see this) at the bottom of magma oceans the pressure 2.5×10^5 times the pressure at Earth.

In versions of this mineral with oxygen vacancies, oxygen ions can become superionic and diffuse rapidly. The mobile O^{2-} may have played a critical role in the oxidation of the early mantle. The oxidation would be very crucial for the understanding of the underground life in the TGD framework.

TGD predicts the possibility of dark ions and an interesting possibility is whether O^{-2} could be dark ions delocalized to the field body. What one can say about the very early Earth just after the formation of Moon. This process generated huge pressure about million time the pressure at the surface of the Earth. The pressure peak induced by the explosion in the core could have generated superionic phases leading to oxidation and the interaction with the FeH superionic phase could have led to the generation of large regions consisting of the Pollack phase of water.

At lower pressures davemaonite transforms to $CaSi$and O_3. $CaSi$is found in crust. Water formed in crust by the of oxygen O^{2-} with protons associated with FeH superionic phase.

To summarize, inn the case of the Earth's core the superionic solid is Fe ion lattice, the mobile element is C, H or O, and the main physical effect is shwar wave softening. In the case of mantle, superionic solid is O or Fe oxide lattice, the mobile element is hydrogen or oxygen ion, and the main effects are enhanced electrical conductivity and rapid mass cycling.

3.9.4 Superionic ice

In the case of water, superionic ice [D1] (`https://cutt.ly/uXUIkUQ` and `https://cutt.ly/3XUIWhX`) existing at extreme pressures is a possible candidate for the exotic phase of water. Superionic ice is proposed to appear in the mantles of giant planets such as Uranus and Neptune and in [L7, L6] the possibility that it could occuring the Earth's mantle was considered. The density of superionic ice is slightly less than 4 times the density of ordinary ice.

Ultrahot 'superionic' ice is a new state of matter. Superionic ice is an exotic form of water existing under extreme heat and pressure, where oxygen atoms form a solid crystal lattice (like ice) while hydrogen ions flow through it like a liquid, making it electrically conductive. Created in labs by zapping water with lasers, this "half-solid, half-liquid" state may be the most common form of water in the interiors of giant planets like Neptune and Uranus, explaining their powerful magnetic fields.

Key characteristics of superionic ice are following.

1. Oxygen atoms form a rigid, crystalline structure (often cubic), while hydrogen ions move freely within it, behaving like a fluid. It forms at extreme pressures (millions of times Earth's atmosphere) and high temperatures (thousands of degrees). The flowing hydrogen gives it metallic-like electrical conductivity, unlike normal ice.

2. Superionic ice helps explain the unusual magnetic fields and internal structure of ice giants.

In the TGD framework one can consider the possibililty that the protons of superionic ice become dark protons at field body of the system. This would give large negative charge to the system consisting of O^{2-} ions generating a very large value of h_{em}.

4 Appendix: Comparison of the model with empirical data

4.1 Testing the predictions from the analogy with Mars with empirical data

The original form of the EE hypothesis makes several unnecessarily strong assumptions about the geological evolution before CE. The comparison with empirical data from this period helps to get rid of these assumptions. I have used discussions with Google Gemini to get empirical data and check various assumptions.

The naive assumption that the Earth is analogous to the recent Mars during the entire period between two BSFRs is too strong. The formation of Martian moons is estimated to have occurred million or at most billion years ago wheres the Moon was formed about 4.5 billion years ago. The analogy between Mars and Earth could be true only some period after the formation of the Moon.

The naive form of the analogy predicts that Earth did not have tectonic activity, continents, and oceans and that and that the radius $R = R_E/2$ and rotational velocit $\Omega = 4\Omega_E$ did not change before CE. This is not true. Is the more realistic version of the hypothesis consistent with the empirical data?

The following compares what Google Gemini tells with TGD view.

1. **Gemini**: Initial "protocrust" appeared in Earth for 4.5–4.2 billion years ago. Following the Moon-forming impact, Earth was covered in a magma ocean that cooled into a solid, stable "quench crust". During this period, the lithosphere was likely a "stagnant lid" (similar to modern Venus) without moving plates. This conforms with the fact that also Mars has crust.

   There is evidence for early localized subduction for 3.8–3.6 billioneears Ago). Recent studies of ancient zircons in South Africa provide the earliest geochemical evidence of subduction—the process where one plate sinks beneath another. This suggests the first instances of crustal "cracking" and movement occurred about 3.8 billion years ago.

   TGD: The absence of subduction and tectonics in Mars is consistent with this.

2. **Gemini**: While oceanic crust is constantly recycled and rarely survives more than 200–340 million years, continental crust is buoyant and preserves much older records.

   (a) The Acasta Gneiss in Canada's Northwest Territories is precisely dated to 4.02 billion years old, represents the oldest preserved continental crust.

   (b) Other ancient "cratons" (stable continental cores) in Greenland, South Africa, and Australia date back over 3.6 billion years.

   (c) Zircons dated to 4 billion years ago contain chemical hints of interaction with freshwater, which implies the existence of landmasses above sea level (terra firma) and a functional hydrological cycle.

   (d) Geologists have mapped several Precambrian supercontinents that preceded the Cambrian, including Vaalbara (3.6 Ga), Kenorland (2.7 Ga), Columbia (2.1 Ga), and Rodinia (1.1 Ga).

   TGD: Also these findings are consistent with the recent situation in Mars.

3. **Gemini**: Oceans of the Earth emerged 4.4 billion years ago with evidence coming from ancient zircon crystals. Oceans emerged in 100 million years. The presence of liquid water oceans is verified back to at least 4.3 to 4.4 billion years ago, shortly after Earth's formation.

   (a) Analysis of the world's oldest known minerals — zircon crystals from the Jack Hills in Australia—reveals high levels of oxygen-18. This isotopic signature indicates that the magmas they formed from had interacted with liquid water at the surface.

   (b) In Greenland, 3.85-billion-year-old pillow lavas (volcanic rocks that only form underwater) and marine sediments provide direct physical proof of stable oceans during the early Archean.

   (c) Fossilized microbial mats (stromatolites) dating back to 3.5–3.7 billion years ago indicate shallow marine environments where early microbial life flourished.

TGD: If the rates of the geological evolutions in Mars and Earth are the same, the absence of oceans in Mars conforms with this finding if Mars was formed 1-100 million years ago.

4.2 Key aharacteristics of Early Earth

According to the Google Gemini, the key characteristics of the Earth before the formation of the Moon were as follows.

1. The intense heat from its formation and continuous impacts kept Earth's surface a molten ocean of lava. There was a violent meteoric bombardment: The early solar system was full of leftover rocky material, leading to constant impacts that bombarded Earth. The rotation period was 6 hrs.

2. There was no solid crust: The surface was a dynamic, fiery landscape, lacking the stable continents and crust we see today. There were no Oceans. Some theories suggest water might have existed, it was mostly vaporized by the heat, with liquid oceans forming much later as the planet cooled.

After the formation of the Moon, the Earth began to cool, allowing heavier elements to sink to the core and lighter ones to form a crust, while the Moon's orbit gradually slowed Earth's rotation over millions of years. Volcanic outgassing and water delivery from comets eventually led to the formation of the Earth's atmosphere and oceans, paving the way for life. The surface temperature likely peaked between 2,300 K and 3,000 K. The entire mantle was effectively liquefied into a global magma ocean.

TGD: In the TGD view of the formation of the Moon, the explosion of a part of the core threw away a layer of thickness of about $R_E/8$ which contained crusts and also part of the core. This predicts that the surface was in magma state even if there might have been a solid crust before the explosion. The study of the Moon might give information about the possible presence of the crust. The near and far sides of the Moon are indeed different and this might relate to the presence of the crust if these sides correspond to the opposite sides of the layer thrown out.

4.3 The formation of the inner core

Google Gemini provides the following information about the formation of the inner core known also as the "iron catastrophe".

The differentiation of Earth's core into a separate liquid outer core and solid inner core did not happen at the same time. While the general iron core formed very early, the solid inner core is a much more recent feature in Earth's history.

1. Initial Core Formation (The "Iron Catastrophe")

   (a) The general metallic core formed approximately 4.5 to 4.6 billion years ago, within the first 10 to 30 million years of Earth's existence. Intense heat from radioactive decay and gravitational energy melted the "proto-Earth".

   (b) Heavy metals (mostly iron and nickel) sank to the center, while lighter silicates rose to form the mantle. At this stage, the entire core was likely a single, molten (liquid) mass of metal.

   TGD: The TGD based model for the formation of the Moon suggests that "cold fusion" in part of the core led to the formation of molten metal core. In Mars this situation have not yet been reached if its moons were born for million years ago.

2. Emergence of the Solid Inner Core

   The solid inner core began to "freeze" out of the liquid outer core much later as the planet cooled. There is ongoing scientific debate about the exact timing, but recent research provides three primary windows:

   (a) Common Estimate: Most recent models suggest the inner core began crystallizing between 1 billion and 1.5 billion years ago.

(b) Younger Estimate: Some studies suggest it could be as young as 500 to 565 million years old.

(c) Older Estimate: Other research argues it may have started forming up to 2 billion years ago.

TGD: The younger estimate is consistent with the proposal that the EE event was accompanied by the solidification of the core of its transition to superionic phase.

3. Recent Discoveries (2025–2026)

   Research published as recently as 2025 and 2026 has added new complexity to our understanding of the core's structure:

   (a) Innermost Inner Core: Scientists have identified a "inner inner core"—a distinct 400-mile-wide metallic ball at the very center—that may have formed due to a radical geologic change roughly 500 million years ago.

   (b) Shape-Shifting: 2025 studies detected that the boundary between the inner and outer core is dynamic and has "shifted" or "deformed" by over 100 meters in height in some places over just the last two decades.

   (c) Rotational Changes: Data from 2024 confirmed that the inner core's rotation began to slow around 2010 and may now be revolving slightly "backward" relative to the rest of the planet.

4.4 Why Mars lacks plate tectonics

Scientific consensus identifies several primary factors explaining the absence of plate tectonics.

1. Smaller Size and Faster Cooling: Mars is roughly half the size of Earth. Smaller planets lose heat much faster; Mars likely cooled so quickly that its interior no longer provides the massive convection currents needed to break and move crustal plates.

2. Lack of Liquid Water: On Earth, water acts as a "lubricant" in the mantle, allowing rigid plates to slide and subduct. Mars is extremely dry, and its rigid crust is too strong and brittle to initiate the subduction process.

3. Thick, Rigid Crust: The Martian crust is roughly 60 km thick, much thicker than Earth's oceanic crust. This thickness acts as an insulating "lid" that prevents the internal heat from breaking the surface into plates.

4. Vertical Tectonics: Research from 2024 and 2025 suggests that instead of horizontal movement (like Earth), Mars experienced "vertical tectonics" early in its history, where the crust recycled itself through sinking and rising plumes rather than plate boundaries.

4.5 The angular momenta of the Earth and Mars

In 2026, Earth's spin is characterized by several high-precision physical values. While the day is commonly referred to as 24 hours, its exact "spin" parameters involve more specific measurements of angular velocity and momentum. The value of the spin is approximately 7.05×10^{33} kg $\cdot$ m^2/s.

Google Gemini provides the following information about the angular momentum of Mars and its moons.

1. The orbital angular momenta of Phobos and Deimos are approximately 9.0×10^{21} kg m^2/s and 2.3×10^{21} kg^2/s, respectively. The spin angular momentum of Mars is approximately 2.6×10^{28} kg^2/s. The values provided below are approximate, as the moons are irregularly shaped and Mars has a non-uniform density, but they offer an accurate order of magnitude comparison.

2. The spin angular momentum of Mars is vastly greater (by several million times) than the orbital angular momentum of either of its small moons. Phobos, despite being more massive than Deimos, has a larger orbital angular momentum due to a combination of its mass and orbital distance/speed characteristics. Both Phobos and Deimos are tidally locked, meaning their rotational period matches their orbital period. Their spin angular momentum around their own axes is negligible compared to their orbital angular momentum around Mars.

3. Phobos orbits below the synchronous orbit radius and is slowly spiraling inward toward Mars, which transfers angular momentum to Mars and slightly increases the planet's spin rate over time. Deimos orbits farther out and is slowly spiraling away from Mars.

4. The relatively low total angular momentum of the Mars system, especially compared to the Earth-Moon system, suggests the moons might have formed from a giant impact event rather than being captured asteroids, though both theories are still explored.

TGD: The TGD based model for the formation of the moons of the Mars is discussed in [L15].

4.6 Magnetic field of the Earth

The most important stages and phenomena in the development of the magnetic field according to Google GEmini are as follows.

1. Early dynamo (c. 3.7–4.2 billion years ago): According to the latest studies published in 2024, the Earth had a magnetic field similar to the present one at least 3.7 billion years ago. At that time, the field strength was about half of the current one, which was enough to protect the atmosphere from the early Sun.

2. Core solidification and "revival" occurred for c. 0.6–1 billion years ago) The magnetic field was close to collapse at the end of the Precambrian (c. 590–565 million years ago), when it was exceptionally weak. The field strengthened again when the Earth's inner core began to solidify, which enhanced the electrically conductive currents in the outer core.

TGD: The TGD view of the magnetic field is not the same as the Maxwellian view. The presence of a magnetic field similar to the recent one at least 3.7 billion years conforms with the absence of the magnetic field in Mars.

Core solidification of the inner core and the revival of the magnetic field could relate naturally to the occurrence of the second BSFR implying explosion. The inner core could have also become a superionic. The increase of the Earth radius by factor 2 made currents possible on a much longer scale and increased the magnetic field strength.

4.7 The triggers for the Cambrian Explosion

What happend in CE. Also here I represent what Google Gemini tells and compare it with the TGD view.

1. **Gemini**: The transition into the Cambrian (approx. 539 Ma) is marked by a massive rise in sea level that flooded these ancient continents.

   TGD: The massive rise of sea level could be interpreted in terms of the burst of the water from underground oceans induced by the explosion that occurred in the inner core and caused a strong pressure pulse. It could have induced also rapid expansion of the Earth but this might have occurred already earlier.

2. **Gemini**: The Great Unconformity is a worldwide gap in the rock record where younger Cambrian sediments sit directly atop ancient Precambrian basement rock.

   The Great Unconformity is a massive, planet-wide gap in Earth's geological record, representing hundreds of millions to over a billion years of missing time, where younger, fossil-bearing rocks (like Cambrian sandstone in the Grand Canyon) sit directly atop much older, crystalline basement rocks, with immense erosion having occurred in between.

This profound unconformity signifies a period of intense erosion, likely caused by Snowball Earth glaciations that scoured continents down to near sea level, followed by tectonic uplift and subsequent burial, creating a vast missing chapter in the planet's history.

TGD: The Great Unconformity could be understand as an evidendence for the occurrence of BSFR. The hundreds to billions years of missing time could corresponds to the time reversed period preceiding CE. The discontinuity in geological records could also correspond the occurrence of BSFR.

3. **Gemini**: The erosion of these vast continental surfaces during the Cambrian sea-level rise flooded the oceans with ions like calcium and phosphate, which researchers believe "triggered" the explosion by providing the raw materials for animals to evolve hard shells and skeletons.

   TGD: The TGD based explanation of the emrgence of ions like calcium and phosphate would have been due to the burst of the water from the underground oceans

TGD: The Great Unconformity could be understand as an evidendence for the occurrence of BSFR. The hundreds to billions years of missing time could corresponds to the time reversed period preceiding CE. The discontinuity in geological records could also correspond the occurrence of BSFR.

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