Some Solar Mysteries

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Abstract

This article was inspired by the article "Is the Sun a Black Hole?" by Nassim Haramein. The article describes a collection of various anomalies related to the physics of the Sun, which I have also considered from the TGD point of view. The most important anomalies are the gamma ray anomalies and the missing nuclear matter of about 1500 Earth masses. There is also evidence that the solar surface contains a solid layer: something totally implausible in the standard atomic physics. The idea that the Sun could contain a blackhole led in the TGD framework to a refinement of the earlier model for blackhole-like objects (BHs) as maximally dense flux tube spaghettis predicting also their mass spectrum in terms of Mersenne primes and their Gaussian counterparts. The mass of the Sun and the mass which is 4/3 times the mass of the Earth belong to this spectrum.

It however turned out that the TGD based model for the missing nuclear matter could assign the gamma ray anomalies to the magnetic body of the Sun consisting of monopole flux tubes. A magnetic bubble as a layer would cover the surface of the Sun and consist of closed monopole flux tube loops. One option is the analog of a dipole field containing flux tube portions along the magnetic axis from South to North and returning along the solar surface from North to South. Also the solar nucleus could contain M_{89} nucleons.

The flux tubes could carry M_{89} nucleons with a mass, which is 512 times the mass of the ordinary nucleon. They could be characterized by the gravitational Planck constant of the Sun with gravitational Compton length equal to $R_E/2$ for all particles (R_E refers to the Earth radius). Intriguingly, the Sunspot size is of the order of $R_E/2$. This flux tube structure, predicted to have a mass of order $1500M_E$, would correspond to one dark M_{89} nucleon per the Compton volume of the ordinary M_{89} nucleon so that the analog of supra phase with very large overlap between wave functions would be in question.

M_{89} nucleons at the monopole flux tubes at the surface of the Sun would produce in the decay to ordinary nuclei the solar wind and solar energy. In p-adic cooling, the splitting of the flux tubes to ordinary nucleons of the solar wind by reconnection would also liberate the radiation from the Sun.

The magnetic body carrying long strings of M_{89} nucleons could be seen as a 2-D surface variant of the TGD counterpart of blackhole, which is dark. This model conforms with the earlier model of the sunspot activity related to the reversal of the solar magnetic field.

An additional input is provided by the model for dark nucleons applied in the models of "cold fusion" and pre-stellar evolution. The conservative option is that the heating by the dark fusion ignites the ordinary nuclear reactions giving rise to the high temperature stellar core. The non-conservative option allowed by the role of the M_{89} layer is that, not only the convective zone but also solar core could consist of dark nuclei at temperature of order 10 keV and hot fusion is replaced by the scorned dark fusion.

A possible explanation for the gamma ray anomalies would be in terms of M_{89} and M_{79} mesons generated in the TGD counterpart for the formation of quark gluon plasma in a process analogous to high energy nuclear collision creating very high nuclear densities. The decay of M_{89} nucleons to ordinary nucleons of solar wind in p-adic cooling would generate anomalous gamma rays. $M_{G,79}$ mesons could be also generated in the touching of two M_{89} flux tubes, whose distance would be larger than 2 Compton lengths of M_{89} (M_{107}) nucleons.

The generation of M_{89} nucleons is necessary. The monopole flux tube network connecting stars to a network analogous to a blood circulation feeds the M_{89} nuclei burned to ordinary nuclei inside the Sun. This option looks the plausible one. One cannot exclude the regeneration could be also p-adic heating as the reversal of the p-adic cooling. In zero energy ontology (ZEO) it could be associated with a "big" state function reduction (BSFR)in solar scale in which the arrow of time changes and the process can be seen as a decay process with a reversed arrow of time: the system would effectively extract energy from the surroundings. Also in TGD inspired quantum biology this kind of process takes place and makes homeostasis possible. That ordinary fusion could provide the needed metabolic energy seems implausible.

A dramatic modification of the views of the interior of the Sun is suggestive. The M_{89} surface layer of the Sun would produce both the solar wind and solar energy and feed energy to the interior of the Sun. The interior could be a quantum system at relatively low temperature of order 10 keV. It would be a quantum criticality making possible dark fusion explaining the "cold fusion". The strong analogies with the TGD inspired quantum biology suggest that the M_{89} layer is analogous to the cell membrane and solar interior to a cell interior. The solar core could correspond to the solar nucleus carrying the solar genome. Stanislav Lem's Solaris is what comes into mind!

The quantum model leads also to a proposal for the generation of the inner planets and Mars via the explosion of the outer layer of the Sun consisting of M_{89} nuclei (dark M_{107} nuclei) to M_{107} nuclei. For the M_{89} option the conservation of baryon number dictates the mass of the structure form in this way to be at most of the order of $3M_E$. The explosion would give rise to the inner planets and cores of the outer planets, which would have got their gas envelopes by gravitational condensation. This model generalizes to a model for supernovas and generation of solar wind. The anomalies related to solar convection and solar neutrinos suggest that the standard model for solar interior must be replaced with a generalization of the nuclear shell model proposed already earlier.

1 Introduction

This article was inspired by the article "Is the Sun a Black Hole?" by Nassim Haramein [L25] (see this). The article describes a collection of various anomalies related to the physics of the Sun, which I have also considered from the TGD point of view. The idea that the Sun could contain a blackhole led in the TGD framework to a refinement of the earlier model for blackhole-like objects (BHs) as maximally dense flux tube spaghettis predicting also their mass spectrum.

1.1 Brief summary of the anomalies

Haramein discusses various poorly understood empirical findings of astrophysics concentrating mostly on the physics of the Sun. Also the physics of Earth and Moon contains mysteries that I have discussed in [L4, L10, L18, L17, L24].

1.1.1 Scaling law of Carr and Rees

A linear scaling law relating the logarithms of masses and size scales of astrophysical objects proposed by Carr and Rees [E5] (see this) has a nice interpretation in the TGD framework. The structures in question would correspond to tangles of flux tubes characterized by string tension as energy density. The coefficient of the linear graph is determined completely by the linearity and string tension only shifts the graph.

1.1.2 Solar abundance problem

Solar nuclear physics involves anomalies [E3, E27, E17, E10], which I have discussed in [L7]. Asplund et al found that C, N, O, and Ne abundances in the Sun are considerably lower than expected: the metallicity of the Sun is unexpectedly low (here "metal refers to any element heavier than ^{4}He). This means a conflict with helio-seismography and solar interior models. Something seems to be wrong with the helio-seismography. About $1500 M_E \sim 9 \times 10^{24}$ kg mass is missing and does not consist of ordinary nuclei.

Mehr Un Nisa [E15] has proposed that some kind of dark matter could be in question. The problem is to understand how this dark matter could yield the gamma ray anomaly. The second proposal [E6, E25, L25] is that the Sun contains a blackhole with a mass of 1500 Earth masses. Could the Sun contain a blackhole-like object (BH)? The radiation emanates from the surface of the Sun which suggests that BH cannot be in the core. Already Hawking considered the possibility of light BHs [E26] and in [E16] light primordial blackholes have been discussed. The findings of James Webb telescope motivate the study of primordial supermassive blackholes [E12].

In TGD, the BH would be maximally dense flux tube spaghetti. Also in this case one must understand how the radiation manages to get to the surface of the Sun from its interior and in the TGD framework a natural option is that it propagates along magnetic flux tubes as dark photons. One can also consider an alternative option. Magnetic bubbles [L19, L20] are surface layers of astrophysical objects: could a magnetic bubble generate the anomalous gamma rays?

Note that the low metallicity could lead to problems in the understanding of nuclear abundances outside the Sun. Solar corona has a very high temperature, which is by an order of magnitude lower than the ignition temperature for nuclear fusion. The density of the solar corona is however extremely low. TGD predicts dark nuclear fusion, which explains "cold fusion" [L2, L1, L9]. It could also occur also at the planets [L19] and in the TGD framework it could give rise to proto-stars and explain the origin of nuclei heavier than Fe. The density in the solar looks quite too low for the cold fusion to occur. Cold fusion could however occur inside the convective zone and even inside the core if M_{89} physics at the surface is responsible for the solar energy flux and solar wind.

1.1.3 The TeV Sun

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The Quanta Magazine article "The Sun is stranger than the astrophysicists imagined" (see this) tells about the unexpected findings related to the gamma ray spectrum of the Sun. The gamma ray flux from the Sun up to TeV energies is not possible to understand in the model based on standard nuclear physics [E15, E14, E4, E9].

High energy gamma rays spectrum of the Sun is anomalous in the region between GeV-TeV range and cannot be understood in terms of standard nuclear physics. The gamma ray emission spectrum also has a dip around 30-50 GeV.

The standard model is based on inverse Compton scattering of cosmic rays. High energy gamma rays would be produced as cosmic rays turn backwards and produce pions, which decay to gamma pairs. This proposal cannot however explain the presence of high energy gammas. There are 10-20 times higher emissions below TeV rane and 30 times higher emissions in TeV range. This raises the question whether the Sun itself could serve as a source of high energy gamma rays.

One can imagine several mechanisms generating the gamma rays: fission, nuclear transmutations by fusion, matter-antimatter annihilation and synchrotron brehm-strahlung in extremely strong magnetic fields . The basic problem is that the diffusion of the gamma rays to the surface transforms them to low energy radiation (absorption, re-emission, scattering).

In the standard physics framework, this leaves only magneto-brehm-strahlung under consideration. Radiation from 100 TeV to PeV has been observed arriving from the galactic nucleus believed to originate from the supermassive blackhole Sagittarius A* in the center of the galaxy [E11]. Black holes, pulsars and magnetars produce this kind of radiation so that only blackholes remain under consideration.

A further intriguing finding is that the high energy gamma ray emission anticorrelates with the sunspot cycle so that the emission is minimum during the reversal of the magnetic field. The emission is strongest towards the North pole. This supports the view that the emission occurs at the surface layer of the Sun.

Note that there are also terrestrial gamma ray flashes associated with thunderstorms. The energy scale is 20 MeV and could have an origin analogous to the solar gamma ray emissions.

1.1.4 Could Sun have a solid surface?

There are indications that the solar surface could contain solid parts [E23]. This anomaly was not mentioned by Haramein but I have discussed it years ago from the TGD point of view [K8].

Recently new satellites have begun to provide information about what lurks beneath the photosphere. The pictures produced by Lockheed Martin's Trace Satellite and YOHKOH, TRACE and SOHO satellite programs are publicly available on the web. SERTS program for the spectral analysis suggests a new picture challenging the simple gas sphere picture.

The visual inspection of the pictures combined with spectral analysis has led Michael Moshina to suggest that the Sun has a solid, conductive spherical surface layer consisting of calcium ferrite. The article of [E23] provides impressive pictures, which in my humble non-specialist opinion support this view. Of course, I have not worked personally with the analysis of these pictures so that I do not have the competence to decide how compelling the conclusions of Moshina are. In any case, I think that his web article of Moshina deserves a summary.

Before SERTS people were familiar with hydrogen, helium, and calcium emissions from the Sun. The careful analysis of SERTS spectrum however suggests the presence of a layer or layers containing ferrite and other heavy metals. Besides ferrite, SERTS found silicon, magnesium, manganese, chromium, aluminum, and neon in solar emissions. Also elevated levels of sulphur and nickel were observed during more active cycles of the Sun. In the gas sphere model these elements are expected to be present only in minor amounts. As many as 57 different types of emissions from 10 different kinds of elements had to be considered to construct a picture about the surface of the Sun.

Moshina has visually analyzed the pictures constructed from the surface of the Sun using light at wavelengths corresponding to three lines of ferrite ions (171, 195, 284 Angstroms). On the basis of his analysis he concludes that the spectrum originates from rigid and fixed surface structures, which can survive for days. A further analysis shows that these rigid structures rotate uniformly.

The existence of a rigid structure idealizable as a spherical shell in the first approximation could by previous observation be interpreted as a spherical shell corresponding to $n = 1$ gravitational Bohr orbit of a planet not yet formed. This structure would already contain the germs of iron core and of crust containing Silicon, Ca and other elements.

There is also another similar piece of evidence [E24]. A new planet has been discovered orbiting around a star in a triple-star system in the constellation Cygnus. The planet is a so-called hot Jupiter but it orbits the parent star at a distance of .05 AU, which is much less than allowed by current theories of planetary formation. Indeed, the so-called migration theory predicts that the gravitational pull of the two stars should have stripped away the proto-planetary disk from the parent star. If an underlying dark matter structure serves as a condensation template for the visible matter, the planetary orbit is stabilized by Bohr quantization.

There is however a problem: the ordinary iron becomes liquid at temperature 1811 K at atmospheric pressure. Using for the photospheric pressure p_{ph}, the ideal gas approximation $p_{ph} = n_{ph}T_{ph}$, the values of photospheric temperature $T_{ph} \sim 5800$ K and density $\rho_{ph} \sim 10^{-2}\rho_{atm}$, and idealizing photosphere as a plasma of hydrogen ions and atmosphere as a gas of O_2 molecules, one obtains $n_{ph} \sim .32n_{atm}$ giving $p_{ph} \sim 6.4p_{atm}$. This suggests that calcium ferrite cannot be solid at temperatures of order 5800 K prevailing in the photosphere (the material with highest known melting temperature is graphite with melting temperature of 3984 K at atmospheric pressure). Thus it would seem that dark calcium ferrite at the surface of the Sun cannot be just ordinary calcium ferrite. What could this new kind of matter be?

1.1.5 Further solar anomalies

There are also further solar anomalies discussed in the article of Haramein [L25]. Not all of them are absolutely essential for the discussion of the TGD based model.

1. The theoretically predicted solar convection is too weak to explain empirical facts about heat transfer in the convective zone. In the TGD framework the notion of monopole flux tube is a natural seat of the convection [E19].

   One can also make a really radical questions? Is the solar interior something totally different from what we have used to think. Is there any fusion in the solar interior? What gives rise to the solar wind?

2. The anomalously high temperature of the solar corona is poorly understood. Temperature is 3 orders of magnitude higher at the solar corona than at the solar surface and there is emission of high energy X rays (see this). The temperature is about 1 million Kelvin whereas the ignition temperature for nuclear fusion is 15 million Kelvin. TGD predicts dark fusion explaining the "cold fusion" and it would play a key role also in the formation of the Sun and also other astrophysical objects.

3. Sunspot cycle having half-period of 11 years is one of the poorly understood aspects of the Sun. What happens is that the polarity of the solar magnetic field changes with a period of 11 years.

   The high energy gamma ray emission [E14] anti-correlates with the solar cycle so that the emission is minimum during the reversal of the magnetic field. Furthermore, the emission is largest towards North pole [E4]. I have proposed a TGD based model for the sunspot cycle [L20] and this anomalous gamma rays are a surface phenomenon, and their emission correlates with the sunspot cycle, it is natural to start the model building from this model.

4. Solar neutrino problem, that is the fact that the observed neutrino flux is considerably lower than predicted by the standard solar model, is usually assumed to be due to the mixing of neutrinos as they travel from Sun to Earth. The article of Haramein [L25] challenges the notion of neutrino mixing. The proposal is that τ and μ neutrinos could be produced if the temperature in the solar core is much higher than it is believed to be. There is however strong

evidence for neutrino mixing from experiments which use atmospheric neutrinos, reactor neutrinos or neutrinos from particle accelerators.

5. There is evidence for the correlation between the solar neutrino flux and solar wind and solar activity and for anticorrelation between solar neutrino flux and the number of sunspots [E1, E21]. It is however argued that the anticorrelation with the sunspot number does not exist [E18]. In the framework of standard physics this looks strange if one believes that the production of neutrinos takes place in the interior of the Sun.

   This forces us to ask whether the origin of solar neutrinos is what it is believed to be. One can also challenge the existing beliefs about whether the convection is the origin of the solar wind and whether it could be generated at the surface layer of the Sun. Could the standard narrative about the interior of the Sun be completely wrong?

1.2 A brief summary of the TGD based model explaining the anomalies

The following gives a brief summary of the TGD based model of the missing solar nuclear matter. Although it turned out that BHs are not needed, one ends up with a model of BHs predicting their mass spectrum in terms of hierarchy of hadron physics labelled by Mersennes primes and their Gaussian counterparts.

The model extends the existing nuclear physics model of the Sun by adding the explanation of the missing nuclear matter in terms of nuclei of M_{89} hadron physics. The model strongly suggests that the stars are analogous to living systems receiving metabolic energy as M_{89} nuclei from the galactic nucleus along monopole flux tubes defining an analog of blood circuitry. Also a quantum model for stars and planets as analogs of nuclei and atoms, based on the new space-time concept and quantum physics predicted by TGD, emerges.

1.2.1 A TGD based model for the magnetic field of the Sun

I have considered TGD inspired models for the reversal of the magnetic field of the Sun during the Sunspot maximum. Magnetic fields in the TGD framework can consist of monopole flux tubes [L8, L19, L20]. The most recent view is that the long closed monopole flux tube loops running from North to South and back at the surface of the Sun split during the polarization reversal by a reconnection to short flux loops which turn and reconnect back to long flux tubes with opposite direction. Could anomalous gamma rays below 35 GeV be associated with them?

Monopole flux tubes would appear in all scales. In particular, if the stars form a lattice-like network, hyperbolic tessellation, as the based model for the gravitational hum [L21] as gravitational diffraction suggests, there would be monopole flux tubes connecting Sun to other stars. The connecting flux tubes would run in a North-South direction through the Sun or at the surface of the Sun. These flux tubes would be different from the flux tubes associated with the magnetic bubble at the surface of the Sun.

Could these monopole flux tubes form a flux tube spaghetti in the center of the Sun? Could they give rise to possibly dark BH or BHs, having a size scaled up by h_{eff}/h? The BH does not look plausible.

This leads to the following proposal.

1. The anomalous gamma rays below 35 GeV range suggest that the flux tubes running along the surface of the Sun contain nucleons of M_{89} physics with mass, which is 512 times the mass of the ordinary nucleon. The missing nuclear mass about $1500 M_E$ would be naturally associated with this kind of layer. The gamma radiation in the TeV range requires a generation of M_{79} phase for which pion decays would produce gammas in the TeV range. The transformation of M_{89} nuclei to ordinary nuclei liberates a huge, probably too huge, energy. There are indications for both M_{89} and M_{79} mesons as bumps at LHC [K5, K6]. This transformation can however take place in steps so that the p-adic prime $p \simeq 2^k$, increases in steps: $k = 89 \rightarrow 87 \rightarrow ... \rightarrow 107$ to avoid huge kinetic energies of the final state nucleons.

   The model for the magnetic body as an analog of a dipole field suggests that the analog of a dipole in the deep interior of the Sun contains M_{89} nuclei. They could be feeded to the Sun from outside, say galactic M_{89} BH, and further feeded to the magnetic bubble at the surface of the Sun, where M_{89} nuclei are burned to ordinary nuclei by p-adic cooling generating the solar wind and solar radiation. Otherwise the p-adic heating, as a time reversal of p-adic cooling in ZEO, is needed. It is far from clear whether ordinary nuclear energy allows the regeneration of M_{89} nuclei.

2. Monopole flux tubes can also contain dark M_{107} nuclei, which could be formed at low temperatures by dark fusion. Their decay to ordinary nuclei would give rise to "cold fusion" [L2, L9] liberating almost all ordinary nuclear binding energy. Dark fusion would also heat the nuclear matter to ignition temperature for the ordinary fusion at the surface of the core. Also in this case, anomalous gamma rays might be generated by the creation of M_{89} and M_{79} mesons.

   Dark fusion would take place in the convective zone and solar corona, where the temperature for the ordinary fusion is not high enough. In the solar core, ordinary fusion would take place. One could imagine the p-adic temperature increases by steps inside the core and corresponds to M_{89} at the center. This would be caused by heating by the decay of M_{89} nuclei in the center, or less plausibly, by the energy feed from the ordinary nuclear reactions.

One can also consider a more refined model of replacing the flux tube spaghetti with magnetic bubbles. This model [L22] inspired by a generalization of the proposal of Nottale that the solar system is analogous to the atom so that the Sun itself is modelled using a generalization of the nuclear shell model [L22]. Magnetic bubbles as 2-D structures analogous to nuclear shells and consisting of monopole flux tubes [L19, L20].

The Sun and planets would be analogous to rotating rigid bodies in a complete analogy with the TGD based model of nuclei and atoms [L15]: the flux tube bonds acting like strings would prevent the gravitational collapse. The simplest model is as a rigid body analog of a gravitational harmonic oscillator (constant density). Also decomposition to separate rigid bodies with different rotation frequencies is possible.

Matter would be located at shells analogous to those in the nuclear shell model. The matter at the flux tubes would be nuclear strings as nuclei of M_{89} or M_{197} hadron physics. If the average matter density is constant, the spherical mass shells as magnetic bubbles would correspond to harmonic oscillator orbitals.

In this framework, the outermost solar layer would be the analog of the outermost shell of atoms and to a high degree determine the interactions with the external world. The explosions of the entire outer shells would create planets and solar wind would be created by local explosions of the outer shell: the total baryon number of the M_{89} shell with mass $1500M_E$ corresponds to a baryonic mass of $3M_E$. The evolution of the star would gradually use the outer shells instead of the nuclear fuel at the core. Note that this picture conforms with holography: all information about solar physics could be contained by the surface of the Sun.

1.2.2 The TGD based model for the anomalous gamma emissions

TGD strongly suggests the existence of a hierarchy of hadron physics, and therefore also of nuclear physics, labelled by Mersenne primes and their Gaussian counterpart [K8]. This a dramatic prediction and the fascinating possibility is that the physics of the Sun could demonstrate the existence of this hierarchy.

The emission below 35 GeV could be assignable to the decay of mesons of M_{89} hadron physics. The mass of M_{89} pion is around 72 GeV so that the gamma ray emissions below 35 GeV so that the dip between 35-50 GeV could be understood. $M_{G,79}$ hadron physics would be responsible for the TeV emission from the decays of $M_{G,79}$ mesons. The mass of $M_{G,79}$ pion would be around 1.5 TeV and could explain TeV emissions: now the gap would be above .75-1.5 TeV. The decay of M_{89} nuclei to $k > 89$ nuclei by the p-adic cooling would generate high energy gamma ray radiation. The radiation in the TeV range would require generation of $M_{G,79}$ pions locally or even the presence of $M_{G,79}$ nuclear strings. For the dark M_{107} nuclei, also M_{89} pions would be generated in this way.

I have earlier considered gamma ray anomaly in the TGD framework [K8, K9] [L8] assuming that Sun corresponds to a monopole flux tube tangle and the anomalous high energy gamma rays are dark cosmic rays arriving along flux tubes as dark radiation with a minimal dissipation. If the Sun is feeded by M_{89} nuclei, this kind of picture also applies now.

1.2.3 TGD based model for the missing nuclear mass

The finding of Asplund et al [E3, E27, E17, E10, E2] strongly suggests that the abundances of nuclei in the Sun are lower than expected. If taken seriously, it suggests that 1500 Earth's masses of ordinary nuclear matter is missing and realized in some other form. I have considered this anomaly in the TGD framework already earlier [L7].

One of the proposed interpretations for the missing mass is as a blackhole of mass of $1500M_E$ and radius 15 m. Also the interpretation as some kind of dark matter can be considered and if monopole flux condensate is in question also this interpretation makes sense.

1. BHs characterized by Mersenne primes need not be in question in the TGD framework but if this the case, a given exotic nucleon would take the volume defined by the Compton length of the nucleon. The condition that the interpretations as a volume filling effectively 1-D flux tube and maximally dense 3-D structure make the same prediction for the radius of the M_k object predicts, fixes the mass of the BH for a given k and it scales like 2^{-k}.

2. Amazingly, for M_{89} the BH has in a good approximation the Earth mass and for M_{107} it has solar mass! There is however no Mersenne prime predicting a blackhole with mass about $1500M_E$ so that the missing mass could correspond to possibly dark M_{107}, M_{89} or $M_{G,79}$ nuclear matter.

The findings reported by Moshina [E23] suggest that the solar surface contains regions, which consist of solid matter made of atoms behaving like ordinary atoms. In the TGD framework, their existence at such high temperatures suggests that the solar surface could contain atoms, whose nuclei consist of possibly dark M_{107} nucleons or M_k nucleons with $k < 107$, which also have essentially the same spectrum as the ordinary atoms.

How does the proposed model relate to this finding?

1. The model predicts closed M_{89} monopole flux tubes plus the dipole in the center of the Earth running along the solar surface should give rise to a very dense object (1500 Earth masses), a kind of surface blackhole would be in question. If the missing mass about $1500M_E$ is realized as a surface layer of M_{89} flux tubes, the flux tube distance is not larger than 2 Compton lengths of M_{89} nucleon and they could touch. This density looks at first quite too large. This explains naturally the generation of M_{89} mesons decaying to M_{89} pions and generating gamma ray pairs with center of mass energy below 36 GeV.

2. The idea about a surface layer of thickness of about $\lambda_N(89) \sim 10^{-18}$ m looks outlandish. If the M_{89} matter is dark with gravitational Planck constant of the Sun. In this case the thickness of the M_{89} layer would be given by $\Lambda_{gr} = r_s(Sun)/2\beta_0$. For $\beta_0 \simeq 2^{-11}$ associated with the planet-Sun pairs [E8], one has $\Lambda_{gr} = R_E/2$ and the thickness is therefore macroscopic. Sunspots have this size scale. For $\beta_0 = 1$ one has $\Lambda_{gr} = 2^{-11}R_E/2 \simeq 1.6$ km. Interestingly, the radii $r_n = \sqrt{n+1/2}r_0$ of orbitals of the gravitational harmonic oscillator have $r_0 = R_E/2$ for $\beta_0 = 1$.

   For $\beta_0 = 1$, a supraphase with extremely high density, one M_{89} dark nucleon with quantum size of 1.6 km per one ordinary M_{89} Compton volume, would be in question. The decay to M_{107} nuclei could take place when the strand develops a fold at which the touching takes place.

3. What about the TeV gamma ray anomaly? The high density would give rise to a generalization of a situation occurring in the laboratory in the high energy collisions of nuclei and leading to what is in QCD framework interpreted as a creation of quark gluon plasma but in TGD framework interpreted as a transition from M_{107} hadron physics to M_{89} hadron physics involving a creation of dark M_{89} mesons with the same Compton length as ordinary hadrons have. At the surface of the Sun, this transition would lead from M_{89} hadron physics to $M_{G,79}$ hadron physics. There is evidence for M_{89} and M_{79} hadron physics from physics from forgotten anomalies interpreted originally in terms of SUSY [K5, K6].

4. The ratio of the flow of the baryonic mass from the Sun in solar wind to the power of thermal radiation is known and considerably smaller than one. The model survives this test if the

$M_{89} \rightarrow M_{107}$ transition corresponds to p-adic cooling [K5, K6] as an analog of period doubling occurring as a sequence of transitions in which the p-adic prime is in good approximation halved. $p \simeq 2^k$ increase in a stepwise manner $k = 89 \rightarrow 91 \rightarrow 93... \rightarrow 107$. Only the last steps would produce gamma radiation with so low an energy that it can thermalize. The gamma radiation produced at the previous steps would explain the gamma ray anomalies, for instance as decays of M_k pions. The heating of solar corona would be caused by the kinetic energy of M_{107} nuclei created at the last step.

5. The TGD based model for the Sunspot cycle [L20] suggests that the presence of the sunspots reflects the decay of closed monopole flux tubes parallel to the solar surface consisting of pieces in North-South direction and parallel pieces in South-North direction and slitting to short pieces by reconnection. These flux tubes could have one M_{89} nucleon per Compton length Λ_{89} just like the flux tube filling the M_{89} blackhole.

   The splitting of the flux tubes makes possible the change of the polarity of the magnetic field as a local process involving a rotation of π, like turning a plate upside down. After this the reconnections make it possible to rebuild a monopole magnetic flux with an opposite polarity.

   Sunspots would be the regions where the splitting occurs. Their size scale is given by the Earth radius R_E. One of the numerous mysterious looking numerical coincidences is that the gravitational Compton length of the Sun predicted by the TGD variant of the Nottale hypothesis [E8] equals to $R_E/2$!

6. It should be noticed, that in the transformation of dark M_{107} nuclei, nuclear binding energy about 5 MeV per nucleon is liberated but this energy is much lower than the nuclear mass about 1 GeV transferred to the solar wind. Therefore the idea that solar surface could consist of dark M_{107} nuclei fails.

2 The TGD based model for the solar anomalies

The TGD based model for the findings allows sharpening of the TGD inspired view of BHs as monopole flux tube spaghettis so that the spectrum of BH masses is predicted, of the solar surface as a solid layer, and of the sunspot cycle.

2.1 Basic building bricks of the model

It is appropriate to start by summarizing the basic ideas behind the proposed model for the anomalies of the Sun.

1. Monopole flux tubes carrying stable magnetic fields requiring no currents to create them distinguish TGD from the standard model. Galactic dark matter corresponds to the energy associated with the cosmic strings having magnetic part and volume part. This energy is the counterpart of dark energy. TGD also predicts a hierarchy of effective Planck constants labelling phase of the ordinary matter behaving like dark matter and explaining the baryonic missing matter, whose fraction is known to increase during the cosmic evolution. The reason would be the gradual increase of h_{eff} in number theoretic evolution increasing algebraic complexity measured by h_{eff} as dimension of extension of rationals.

   The phase transitions increasing the thickness of the monopole flux tubes would transform the dark energy to ordinary matter and give rise to analog of inflation [L22] and to rapid expansion periods as kind of mini bigbangs giving rise to an accelerated expansion. The presence of cosmic strings would be essential during early cosmology and they would dominate the primordial cosmology.

   They would both generate ordinary matter and serve as seeds around which hydrogen gas could gravitationally condense. It is indeed known that the standard model, explaining the formation of the galaxies in terms of the gravitational condensation of hydrogen gas to form stars, has difficulties [E7]. There is also a quite recent finding of a galaxy-like structure without stars (see this). The TGD inspired explanation would be that the cosmic strings serving as seeds of stars are absent in this case.

The mini big bangs throwing out magnetic bubbles would rise to the formation of planetary systems and would be the TGD counterpart for the smooth cosmic expansion of the GRT cosmology. TGD cosmology would be fractal involving cosmologies within cosmologies. Expanding Earth hypothesis [L4, L10, L18] and origin of the Moon [L24] are two examples of the applications.

2. In the TGD framework, monopole flux tubes play a key role in astrophysics, hadron physics, nuclear physics, atomic physics, chemistry and even in biology.

3. p-Adic length scale hypothesis [L12] states that primes $p \simeq 2^k$ are of special importance in the TGD Universe. The prime values of k are proposed to be especially special and Mersenne primes M_k and their Gaussian counterparts $M_{G,k}$ are favoured by the mass spectrum of elementary particles.

   In the number theoretic vision p-adic primes are identifiable as ramified primes of polynomials defining the space-time regions. This leads to a proposal for a hierarchy of hadron physics labelled by M_k and their $M_{G,k}$ and also a similar hierarchy of BHs. In the model for the BHs the monopole flux tubes filling the BH volume have one M_k nucleus per Compton length and have Compton length L_k as radius. These BHs would serve as initial states of evolution of astrophysical objects analogous to BH evaporation. ZEO also allows the interpretation as a time-reversed blackhole collapse.

4. Dark fusion is in the TGD framework identified as the predecessor of ordinary fusion creating dark nuclei with small binding energy, which then decay to ordinary nuclei and liberate most of the ordinary nuclear binding energy. Dark fusion could have generated heavy nuclei and could also have heated the temperature of the ordinary matter to the ignition temperature of ordinary nuclear fusion and in this way generated protostars.

This picture would explain several of the mentioned anomalies.

1. The flux tubes connecting Earth and Sun are also required by any reasonable model of the solar wind. Monopole flux tubes would make thermal convection possible by allowing the carriers of thermal energy to move along the flux tubes practically without dissipation.

2. The correlation of the intensity of the high energy gamma ray emission below TeV range with the solar latitude conforms with the view that there exists closed monopole flux tubes running along the solar surface from North to South and back.

3. In the TGD framework, dark nuclear fusion, explaining "cold fusion" [L2, L1, L9] could be the reason for the increase of the temperature at the solar corona [L8] [K3].

4. The TGD view of the solar neutrino anomalies relies on the neutrino mixing. In the TGD framework the mixing of quarks and leptons reduces to the mixing of the topologies of the partonic 2-surfaces associated with them [K5, K6]. The direct production of μ and τ neutrinos could however contribute to neutrino flux.

2.2 Hierarchy of BHs labelled by Mersenne primes and their Gaussian counterparts

What comes first to mind in the TGD framework, is the interpretation of the missing nuclear matter in terms of BHs consisting of exotic nuclear matter in the core of the Sun. The presence of the anomalous gamma radiation however makes this proposal implausible. It however led to a prediction of the mass spectrum of BHs already assigned the hierarchies of Mersenne primes and their Gaussian counterparts [L6].

1. The hierarchies of Mersenne and Gaussian primes are proposed to label scaled variants of hadron physics and corresponding nucleons [K5, K6]. Each hadron physics of this kind gives rise to BHs as nuclear strings, which are maximally dense and fill the entire volume of the BH with a mass which is quantize by the condition that the mass defined by the 3-D formula proportional to the volume and the mass define by the blackhole formula are identical. This assumption implies an explicit list for the masses and radii of BHs.

2. Mersenne primes or their Gaussian counterparts exist and define a hierarchy of p-adic length scales $L(k) \propto 2^{-k/2}$, where k corresponds to $M_k = 2^k - 1$ or $M_{G,k} = (1+i)^k - 1$. The masses of corresponding BHs scale like $M/M_{Sun} = (L(k)/L(107) \simeq 2^{k-107}$ whereas the nucleon masses scales scale like $m(k)/m_p = (L(k)/L(107)^{-1/2} \simeq 2^{-(k-107)/2}$. At the limit of $k = 1$, one has $M/M_{Sun} \to 2^{-106}$. For $M = M_{Sun} \sim 2 \times 10^{30}$ kg, this gives $M(k = 2) \sim 10^{-5}$ kg. Note that Planck mass $m_P \simeq 2.2 \times 10^{-8}$ kg is smaller than this so that a transition to quantum coherent phase characterized by gravitational Planck constant $h_{gr} = GMm/\beta_0$, as a Nature's way to make perturbation theory convergence in presence of quantum coherence, is possible.

3. The list of Mersenne and Gaussian primes allows us to predict the blackhole masses and radii. The list of integers k for the Mersenne primes is $\{2, 3, 5, 7, 13, 17, 31, 61, 89, 107, 127, 521, 607, ...\}$. One has $M(31) \simeq 10^6$ kg and $r_S(31) = 5.3 \times 10^{-20}$ m. The list of Gaussian Mersenne primes is $\{2, 3, 5, 7, 11, 19, 29, 47, 73, 79, 113, 151, 157, 163, 167, 239, 241, 283, ..\}$.

   A hierarchy of black holes with arbitrarily large quantized masses is predicted and these blackholes could serve as initial states of their evolution or as final states of an evolution with an opposite arrow of geometric time.

One can deduce a general mass formula for the BHs from the assumption that the flux tube picture is equivalent with the 3-D picture.

1. Assume that one has a Mersenne prime or Gaussian Mersenne prime M_k characterizing the p-adic length scale $L(k)$ and mass $m(k)$ of the nucleon of the scaled variant of ordinary hadron physics. One obtains for the mass of the system regarded as a 3-D system assuming a maximal density of nucleons with mass $m(k)$.

$$M(k) = \frac{4\pi}{3} \times (\frac{R(k)}{L(k)})^3 m(k) \tag{2.1}$$

   This gives for the radius of the system

$$R(k) = (\frac{3}{4\pi})^{1/3} (\frac{M(k)}{m(k)})^{1/3} L(k) \ . \tag{2.2}$$

2. Assume that the system is a blackhole with radius $R(k) = 2GM(k)$ formed by a volume filling flux tubes containing maximal density of nucleons so that one has $R(k) = 2GM(k)$.

For $\hbar_{eff} = \hbar$, these conditions boil down to the condition

$$2GM(k) = (\frac{3}{4\pi})^{1/3} (\frac{M(k)}{m(k)}))^{1/3} L(k) \ . \tag{2.3}$$

giving

$$M^2(k) = \frac{3}{4\pi} \times \frac{2G)^{-3} L(k)^3}{m} = \frac{3}{4 \times 8\pi} M_P^2 (\frac{L(k)}{l_P})^4 \ . \tag{2.4}$$

where M_P *resp.* L_P denotes Planck mass *resp.* Planck length scale. $L(k)$ denotes the Compton length of the nucleon of M_k hadron physics.

This gives

$$M(k) = \frac{3}{4 \times 8\pi}^{1/2} (\frac{m_P}{m(k)})^2 M_P \ . \tag{2.5}$$

which scales like $m(k)^{-2} \propto 2^{-k}$.

One can consider various cases corresponding to different Mersenne primes associated with the nucleons of the scaled up hadron physics.

2.2.1 M_{107} hadron physics (ordinary hadron physics) and BH with a solar mass

Using $m_P = 1.3 \times 10^{19} m_p$, one obtains

$$M(107) = {\frac{3}{4 \times 8\pi}}^{1/2} \times 10^{57} m_p \ . \tag{2.6}$$

Using $m_p = 1.7 \times 10^{-27}$ kg one has $M = 2.02 \times 10^{30}$ kg which is the mass $M_{Sun} \simeq 2 \times 10^{30}$ kg of the Sun!

This conforms with the earlier proposal that the ordinary blackholes correspond to $k = 107$ that is protons filling the entire volume and also the volume of the flux tubes [L6]. I failed to realize that the earlier model could have predicted the mass of the BHs for given k.

The first interpretation is that a BH with a solar mass has expanded to form the recent Sun. The alternative interpretation, inspired by zero energy ontology, is as a collapse to a BH occurring with an opposite arrow of time. The holography would show its power here. The only holographic data would be mass, angular momentum and charge of the BHs (plus possibly some additional observable in the TGD framework). The interactions of expanding BHs with the external world of course change them but knowing the initial state provides a lot of information and in a certain sense gives rise to the counterpart of the genetic code.

2.2.2 M_{89} hadron physics and BH with a mass of the Earth

The scaling $k = 107 \rightarrow 89$ gives

$$M(107) \rightarrow 2^{-107+89} M \simeq 4 \times 10^{-6} M_{Sun} \simeq 8 \times 10^{24} \text{ kg} \ . \tag{2.7}$$

to be compared with the mass $M_E = 6 \times 10^{24}$ kg of Earth. There is a discrepancy by a factor 3/4. One can however ask whether the Earth could have originated as an explosion (evaporation) of a blackhole with mass $4M_E/3$ or collapsed to it in a reversed time direction! The Schwartshild radius of M_{89} mini BH would be $r_s = .013$ m. By the Nottale hypothesis [E8], $r_s/2\beta_0$ defines the gravitational Compton length. It turns out that a more plausible option is that Earth was formed in an explosion of the M_{89} surface layer of the Sun as it transformed to ordinary M_{107} hadrons.

The nuclei formed from M_{89} nucleons with mass about 512 GeV are predicted. The BH would consist of a very long nuclear string filling the entire volume, a giant nucleus would be in question. In [K5] I have suggested that at the temperature corresponding to the QCD Λ, a phase transition to a dark variant of M_{89} hadron physics with $h_{eff}/h = 512$ leaving the Compton length of ordinary nucleons unaffected could take place. One would have $T \sim .2$ GeV.

M_{89} pion would have mass about 71.7 GeV. The anomalous high energy gamma radiation from the Sun could receive a contribution from M_{89} pions decaying to gamma pairs. Also the dip in the range 30-50 GeV could be understood since the gamma ray energy in the rest system of the pion cannot exceed 36 GeV.

I have proposed [K5, K6] that the value of $h_{eff} = 512h$ characterizes various candidates of M_{89} mesons at LHC created at criticality for the transition, which corresponds in QCD to transition to quark plasma. Therefore the Compton length of the M_{89} nucleons would be that of the ordinary nucleons [K5, K6]. The overlap of the dark M_{89} nucleons would be large and they would form a quantum coherent system analogous to a superconductor. The dark variant of this proposal would predict for $h_{eff}/h = 512$ that the size of the dark BH is of the size of the Sun.

2.2.3 $M_{G,79}$ hadron physics and the TeV anomaly of the Sun

The identification of the missing nuclear mass as a blackhole can be considered also in the TGD framework although it turns out that a surface layer of M_{89} nucleons is a more plausible option. One can still ask whether the Gaussian Mersenne prime $M_{G,k=79}$ might make it possible to understand the mass $M = 1500M_E$ of the proposed blackhole in the solar interior $M_{G,k=79}$. For $M_{G,k=79}$, one obtains by scaling masses $(4/3) \times 2^{89-k} M_E$ giving $r_s = 13.33$ m and $M(79) = 1333 \times M_E$ not far from the $1500M_E$.

The corresponding proton would have mass $m_p(79) = 14 \times 10^3 m_p$ and the scaled variant of pion would have mass $m_\pi(79) = 16 \times 10^3 m_\pi \sim 2.2$ TeV, which would fit nicely with the unexpected radiation at TeV range from Sun.

The hypothetical $M_{G,79}$ BH could be the initial state of an object with mass about $M_E/1000$ and Schwartschild radius $r_s(79) = 10^{-4}$ m consisting of $M(G,79)$ nucleons. Perhaps the most realistic option is that M_{89} and $M_{G,79}$ pions generated in the analogs of very high energy collisions of dark M_{89} nuclei generate the anomalous gamma radiation from the Sun.

2.2.4 M_{61} hadron physics and Bohr radius

The scaling $k = 89 \rightarrow 61$ gives

$$M(61) = 2^{-89+61}M(89) \sim 4 \times (4/3) \times 10^{-9} \times M_E \sim 6 \times 10^{15} \text{ kg} . \quad (2.8)$$

The size of this mini blackhole would be 5.3×10^{-11} m to be compared with the Bohr radius 5.29×10^{-11} m of hydrogen atom! A possible interpretation is that holography=holomorphy vision implies a duality between electrodynamics and gravitation.

Could the gravitational binding energy $E_{gr} = GM_E/R_E \sim 10^{-9}M_E$ of Earth be compensated by the mass $M(61) = 5.3\times10^{-9}M_E$ of the $M(61)$ blackhole? If the radius of Earth was $R_E/2$ before the Cambrian explosion, the gravitational binding energy would have been about $4 \times 10^{-9}M_E$ and there was a surplus energy of $1.3 \times 10^{-9}M_E$.

2.2.5 Could astrophysical objects originate from or end up to Mersenne BHs?

The side product of these consideration is a proposal for the mass spectrum of BHs labelled by Mersenne primes and their Gaussian counterparts.

1. p-Adic length scale hypothesis predicts a hierarchy of hadron physics with nucleons characterized by p-adic length scale, which corresponds to a Mersenne prime $M_k = 2^k - 1$ or Gaussian Mersenne prime $M_{G,k} = (1 + i)^k - 1$ [K5, L6, K10].

2. For a given nuclear physics in the hierarchy of Mersennes, the mass and therefore the size of the black hole-like object are fixed from the condition that the radii are the same: this condition was not applied in the earlier variant of the model, which assumed that blackhole-like entities correspond to monopole flux tubes with a maximal density of nucleons per unit length and filling the entire volume. The mass of BH scale as $M_k \simeq 2^k$ and the mass of the M_k nucleon as $2^{-k/2}$.

3. In the case of ordinary nucleons characterized by M_{107}, one obtains the mass of a solar blackhole with radius of 3 km. For M_{89} nuclei have mass equal to $512m_p$. The mass of the M_{89} BH is rather near to M_E and its Schwartschild radius is near to $r_s(Earth) = .01$ km. The decay of M_{89} mesons could explain the part of the gamma ray anomaly of the Sun below 35 GeV.

   The list of BHs does not contain any BH with mass between solar mass and Earth mass, in particular BH with mass $1500M_E$ is missing.

   The decays of M_{89} *resp.* $M_{G,79}$ pions could explain the anomalous gamma rays below 35 GeV *resp.* anomalous TeV gamma rays. This does not necessitate the presence of M_{89} *resp.* $M_{G,79}$ nucleons.

BHs in the interior of Sun do not seem plausible. The above considerations however lead to a proposal that some astrophysical objects could have formed by an analog of Hawking evaporation of BHs identifiable as tangles associated with cosmic string with the type of object defined by the p-adic length scale characterizing the nucleon.

1. In zero energy ontology (ZEO) they could correspond to a collapse of a BH in the reverse time direction. This process would occur in stepwise manner as TGD analog of continuous cosmic expansion and one obtains a connection with the Expanding Earth hypothesis [L4, L10, L18] and the TGD based model for the origin of Moon [L19, L24].

2. For small p-adic primes the masses of the BHs are very small although they consist of heavy nucleons. For large p-adic primes the masses of nucleons are very small but the masses of the BHs are large and they could correspond to supermassive blackholes. Also dark variants

of these blackholes can be considered and the Nottale hypothesis [E8] should apply also to them [L3, L5, L11, L14, L22].

3. For $M_{G,79}$ ($M_{G,73}$) the BH would have Schwartshild radius 10^{-4} m (1.6×10^{-6} m corresponding to the size of a large neutron (cell nucleus). For M_{61} BH would have size, which very precisely corresponds to the Bohr radius of hydrogen atom! The atomic physics for these Mersennes would be essentially the same as for M_{89} and size scales of atoms would be the same if determined by $\hbar_{gr}(Sun) \equiv \hbar_{gr}(k = 107)$. One can also consider the possibility that the size scale corresponds to other Mersenne primes.

4. The thickness of the convective zone is estimated to be about 2×10^5 km and is by an order of magnitude smaller than $\Lambda_{gr}(Sun) = 3.1 \times 10^6$ km which is one half of the Earth radius. This would allow dark M_{89} BHs characterized $\Lambda_{gr}(Sun) \sim R_E/2$: the wave functions for atomic atoms would however have gravitational Bohr radius $a_{gr} = \Lambda_{gr}/2\alpha = r_s(Sun)/4\beta_0\alpha = R_E/8\alpha \sim 17R_E$, which is considerably smaller than the solar radius $R_{Sun} \sim 109R_E$. For $n = 3$ state the radius of electron orbit would be $155R_E > R_{Sun}$. This would suggest a delocalization of wave functions along monopole flux tubes.

2.3 TGD inspired solution of the abundance problem, a mechanism for the sunspot cycle, and the identification of the missing nuclear mass

The TGD inspired solution of the abundance problem provides a mechanism for the sunspot cycle. Concerning the understanding of the anomalous gamma rays, there are intriguing empirical hints.

1. The gamma ray emissions below 35 GeV could result from the gamma decays of M_{89} pions of mass about about 72 GeV. This would explain the 30-50 GeV gap for the gamma ray emission spectrum. Gamma ray emissions in the TeV range could emerge from the decays of $M_{G,79}$ pions.

2. The lower bound for the size of the sunspots equals the size of Earth. On the other hand, the gravitational Compton length $\Lambda_{gr}(Sun) = r_s/\beta_0$, $\beta_0 \sim 2^{-11}$, of the Sun is dictated by the Nottale hypothesis $hbar_{gr} = GMm/\beta_0$ [E8]. Λ_{gr} is independent of the mass of the particle in question (Equivalence Principle). Rather remarkably, in a good approximation one has $\Lambda_{gr}(Sun) = R_E/2$ for $\beta_0 = 2^{-11}$ predicted by the model of. solar system as an atomic system. Could $\Lambda_{gr}(Sun)$ define a lower bound for the size of the sunspots as quantum structures.

   The problem is that the harmonic oscillator model requires $\beta_0 = 1$. However, in this case the basic length scale r_0 of the oscillator model is $r_0 \simeq R_E/2$. Note that gravitational oscillator model predicts the orbital radii to be $r_n = (r_n\sqrt{(k + 1/2)}r_0$, $r_0/R_{Sun} = 1/\sqrt{2\beta_0}(r_s/R)^{1/4})$. These radii are a good guess also in the model of the Sun as a rigid body.

3. There is spectroscopic evidence [E23] that the solar surface carries ridid structures consisting of particles, which have the spectrum of ordinary atoms. I have discussed these findings from the TGD point of view of gravitationally dark matter in [K8]. These structures rotate with Sun and have a lifetime of few days.

   The existence of these structures is of course in a blatant conflict with the existing view that the solar surface is in plasma phase. The problem is that solid structures formed from atoms such as Fe are unstable at the temperature $T \simeq .57$ eV of the photosphere. If the surface is not in the plasma plasma phase as the identification, as the surface layer defined by the magnetic bubble suggests, the situation changes. Since the atomic binding energies depend only very weakly on the mass of the nucleus, the nuclei of these atoms could be dark M_{107} atoms or M_{89} atoms (possibly dark).

The spectra of atoms with M_k nuclei would be in an excellent approximation same as for the ordinary atoms since the reduced mass is essentially the electron mass. Concerning the definition of dark atoms there are however two options.

1. The first option is that not only particle masses but also binding energies are invariant under the scaling of h_{eff}. The invariance of the binding energies requires that $\alpha_{em} = e^2/4\pi\hbar \simeq$

1/137 is invariant and spectrum does not depend on the value of $\hbar$ so that the M_{89} nuclear matter could be also dark without any effect on the atomic spectra.

2. The second option, that I have adopted earlier and it called theoretician friendly option [L16], relies on the identification $\alpha_{em} = e^2/4\pi\hbar_{eff}$ so that the binding energy scale of atoms depends on h_{eff}.

   This option would guarantee the convergence of the perturbation series in a situation when the couplings strength becomes large. The atomic binding energies would be however extremely small for $\hbar_{eff} = \hbar_{gr}(Sun)$: does the small value of h_{eff} guarantee their stability.

Could (should) one replace the second option with the first one? The answer is "No!".

1. The replacement is not necessary if one assumes that the value of h_{eff} for the electrons of exotic atoms is the same as for ordinary atoms. The atoms would look very much like ordinary atoms except that the nuclei would be much heavier. Dark matter would not add much to the world.

2. The replacement would lead to difficulties with the notion of dark nuclei. Dark nuclei would have the same binding energy as the ordinary nuclei. This would not have however prevented their formation from free nucleons in the dark fusion [L2, L9]: the nuclear binding energy would be liberated in their formation rather than in their decay to ordinary nuclei so that the view about their role might remain essentially unaffected. The possible problems relate to perturbation theory.

3. The increase of various energies with h_{eff} plays a key role in the TGD based understanding of metabolism: metabolic energy is needed to increase h_{eff} and therefore to increase complexity defining the evolutionary level of the system. This strongly disfavors the replacement.

Anomalous gamma rays could be associated with the local generation of M_{89} and $M_{G,79}$ pions in the analogs of high energy nuclear collisions usually believed to generate quark gluon plasma. It is not necessary to assume M_{89} or $M_{G,79}$ nucleons.

2.3.1 Are the nuclei at the monopole flux tubes M_{89} nuclei?

M_{89} proposal must survive several consistency tests.

1. Sunspots and the high energy gamma radiation assignable to M_{89} nuclei could be associated with blobs of M_{107} nuclear matter at the surface of the Sun having resulting from the splitting of the monopole flux tubes to short close flux tubes by reconnection and p-adic cooling of M_{89} nuclei. The gravitational Planck constant $\hbar_{gr}(Sun)$ implies that $\Lambda_{gr}(Sun)$ is $R_E/2$. On the other hand, the average size of the sunspots is of order R_E and also smaller sizes are possible.

2. In accordance with the model of [L20], sunspots would result during the sunspot maximum from the slitting of very long monopole flux tubes forming a magnetic bubble at the surface of Sun to closed monopole flux tubes during the sunspot maximum. These flux tubes form 1-D analogs of M_{89} BHs containing one M_{89} nucleon per its Compton length. M_{89} nuclei could be gravitationally dark with $\beta_0 = 1$ as also Sun in the harmonic oscillator mode. However, $\beta_0 = 2^{-11}$ true for the planet-Sun pairs cannot be excluded for the M_{89} matter at the M_{89} magnetic body of the Sun.

3. The density of M_{89} nucleons should be maximal, that is nucleon per M_{89} nucleon Compton length, just as in the collisions of the ordinary M_{107} nuclei believed in the QCD framework to generate the QCD plasma. The basic objection is that the density at the monopole flux tubes at the solar surface is huge. If the M_{89} nuclei are gravitationally dark, their quantum size would be $\Lambda_{gr} = R_E/2$ for $\beta_0 = 2^{11}$ and one would have an analog of have supra phase.

   There is evidence for this process from LHC [K5, K6]. Indeed, the monopole flux tubes carrying M^{89} nucleons could be very near to each other and could touch if their distance is smaller than the dark Compton length $\Lambda_{gr}(Sun)$. This would lead to the dark analog of the high energy nuclear collision, in which the TGD analog of quark gluon plasma as M_{89} mesons with the same quantum size as ordinary mesons is generated. $M_{G,79}$ dark mesons (pions essentially), eventually decaying to TeV gamma rays, would be generated.

4. The mass for a closed M_{89} loop, running along the surface of Sun from the North Pole to the South Pole and back, would be given in terms of the radius $R_{Sun} = 109R_E \simeq 7\times 10^8$, the mass $M(89) = 512m_p \simeq .8\times 10^{-24}$ kg of the M_{89} nucleon, and its Compton length $L(89)L_p/512 \simeq .65\times 10^{-18}$ m, as

$$M(M_{89}loop) = 2\pi y_{89} m_{89} \quad . \tag{2.9}$$

Here one has

$$y_{89} = \frac{R_{Sun}}{L(M_{89})} \simeq 2.7\times 10^{26} \quad . \tag{2.10}$$

This gives $M(loop) \sim 2\pi times 10^2$ kg.

5. If a fraction x solar surface is covered with this kind of loops one has for the mass

$$M(layer) = x\times \frac{8\pi R_{Sun}^2}{\pi L_{89}^2} m_{89} = 4\times x y^2 m_{89} \quad , \tag{2.11}$$

which gives $M(layer) \sim x\times 2\times 10^{29}$ kg, which is by a factor $x/10$ smaller than the solar mass $M_{Sun} \sim 10^3 M_E$. $x = 1.5\times 10^{-2}$ would give $M(layer) = 1500M_E$. The contribution of M_{79}, with 1000 times larger linear mass density, must be rather small and it could be generated by the analog of the phase transition quark gluon plasma from M_{89} nucleons at the flux tube.

6. The number $N(loop)$ of the loops between the North Pole and South Pole can be estimated as

$$N(loop) = \frac{M(layer)}{M(loop)} = \frac{1500M_E}{M(loop)} \simeq \frac{10^{25}}{2\pi} \quad . \tag{2.12}$$

The angular width of single loops at the equator is $\Delta\phi = 2\pi/N$ and the spatial width is $\Delta L = R\Delta\phi$, which gives $\Delta L \simeq 4\times 10^{-18}$ m which corresponds to 2 Compton lengths L_{89} of M_{89} nucleon. Therefore the density of loops is nearly maximal and the model looks realistic.

7. At high latitudes one can avoid the increase of the density over one dark nucleon per ordinary Compton volume if the loops turn back at azimuthal angle θ for which $\Delta L(\theta) = \Delta L sin(\theta)$ is equal to L_{89}. This corresponds to the azimuthal angle $\theta_{min} = \pi/6$ and to the latitude of 60 degrees. Sunspots appear at a latitude of 30 degrees. A more precise estimate could give a more realistic value for θ_{min} defining Compton length as the minimal angle $\Delta\phi$ between neighboring loops.

2.3.2 What is the role of dark M_{107} nucleons?

The development of a new idea consists of periods of euphory and harrowing suspicion. At this time I started from the M_{89} option and the suspicion was that the energy liberated in $M_{89}\to M_{107}$ transitions might be too huge. Could one consider options in which the energy is reduced to the ordinary nuclear binding energy? I have indeed proposed dark fusion as a mechanism liberating the ordinary nuclear binding energy [L6, L7].

Also the dark variants of ordinary M_{107} nucleons can form sequences at the monopole magnetic flux tubes. If the nuclei are ordinary there is one nucleon per Compton length of nucleon, which would give a density of a neutron star but is not expected to make sense for ordinary stars.

In the model for the dark fusion, nucleons are dark in the sense that the effective Planck constant $h_{eff} \sim 2^{10}h$ so that the dark proton Compton length is 1/2 of the electron Compton length and by a factor 2^{10} longer than proton Compton length. This would reduce the nuclear binding energy from few MeV to few keV since, quite generally, the increase of h_{eff} increases energy of the system.

These states can transform to ordinary nuclei and liberate essentially all ordinary nuclear binding energy. The proposal has been [L6] that this phase gives rise to protostars and that eventually ordinary nuclear fusion is ignited as the temperature of the system is raised by the dark fusion. This would occur in ordinary nuclear fusion reactors but does it occur in the Sun? Is dark fusion all that is needed?

"Cold fusion" would be based on this mechanism and could have enormous technological implications [L9] since one can consider the possibility that the cold fusion takes place near the critical temperature at which the dark nuclei are thermally stable. The value of h_{eff} in the "cold fusion" would be such that proton Compton length would be of the order of electron Compton length and the temperature would be of the order of eV prevailing in the solar corona. Could it be that our attempts to realize nuclear fusion involve a horrible misunderstanding: could it be that the quantum criticality for the formation of dark nuclei at temperature of order few keV is the correct approach?

What if the hot fusion in the standard sense requires a generation of the phase in which dark M_{89} mesons with $h_{eff}/h \simeq 512$ are present and have the same Compton length as ordinary mesons and decay to bunches of ordinary mesons. They would decay to ordinary mesons and give rise to hot fusion. In the QCD framework, this would correspond to the deconfinement phase transition at temperature determined by Λ_{QCD} in the range 100-200 MeV and of the order of 10^8 K. If this is the case one could perhaps understand the difficulties of hot fusion for light nuclei.

Dark M_{107} nucleons would appear naturally in the convection zone where energy would be produced by dark fusion. This could explain some of its anomalous features such as anomalously low heat transfer by convection. The core and the convective zone could be rather isolated systems.

Still one can ask whether one could replace M_{89} nucleons of the solar magnetic bubble with dark M_{107} nucleons?

1. The transformation of dark M_{107} nucleons to ordinary nucleons would liberate energy, which is of the order of ordinary nuclear binding energy. Could this be enough. The process producing ordinary nuclei would be dark fusion proposed to explain "cold fusion". Is the solar core needed at all? Is the Sun analogous to an atom or nucleus according to the shell model? The answer to these questions is of course "No!".

2. Could one explain the anomalous gamma radiation at energies below 35 GeV and around TeV? There are indications for the generation of both M_{89} and M_{79} mesons at LHC [K5, K6]. Could local phase transitions create M_{89} mesons (M_{89} nucleons are not necessary!) given rise to gammas with energy below 35 GeV. These phase transitions are assumed to take place in the formation of quark gluon plasma in heavy nucleus collisions involving very high nucleon densities. Could local creation of M_{79} mesons lead to TeV radiation?

3. For ordinary nucleons, the mass of the surface layer would be by factor 2^{-18} smaller than the mass about $1500 M_E$ required by the findings of Asplund [E3, E27]. Why I ended up with the M_{89} option was that it explains this mass. For dark nuclei M_{107} this would make a mass of $4 \times 10^{-4} M_E$. 2^{18} layers of this kind is required and corresponds to a thickness of 2.5 Angstrom, which is atomic length scale. In a neutron star the nuclei could indeed be ordinary.

   The TGD based model for the "cold fusion" as dark fusion [L9] suggests that the value of $h_{eff}/h \sim 2^{10}$ so that nucleon would have dark Compton length which is roughly $L_e/2$ where L_e is the electron Compton length 2×10^{-12} m (note that the parameter $\beta_0 = v_0/c$ in the expression of the gravitational Planck constant of the Sun is approximately 2^{-11} [E8]). If there were one dark nucleon per ordinary Compton volume, there would be 2^{18} layers of thickness L_e giving for the surface layer a thickness of 5×10^{-4} m. If the distance of dark nuclei is equal to dark Compton length, there must be 2^{18+20} layers. This gives a thickness of 500 m. The dark nuclear binding energy is of order keV, which is about 10 times higher than the temperature at the solar corona.

The problem is that although the ordinary nuclear binding energy liberated in the transformation to ordinary nucleons is large, it is much smaller than the ordinary nuclear mass going to the solar wind.

4. One can wonder whether the darkness of the atoms with dark M_{107} nuclei could make them stable despite the high temperature of the solar surface? There is however a problem involved. If the value of h_{eff}/h is 2^{10} for dark nucleons, this suggests that the atomic binding energy scale is reduced by factor $(1/h_{eff})^2$ and exotic atoms look totally different. Also M_{89} atoms should correspond to ordinary M_{89} nuclei since $\hbar_{eff} = \hbar_{gr}$ makes the binding energy scale extremely small. One must be however very cautious with these conclusions since $\hbar_{gr}$ characterizes a pair of systems unlike h_{eff}.

2.3.3 Can the energetics of the Sun be understood?

The energetics related to solar wind and radiation from the Sun provide a killer test for the model. The ratio for the mass carried out by solar wind to the energy carried out by radiation should be consistent with the empirical findings.

The energy lost per year using solar mass as a unit is a convenient measure for the rate of the mass loss in solar wind and for the rate of the energy lost by radiation. In the standard model interpreted as thermal radiation at the surface of the Sun acting as blackbody radiation.

The experimental estimate for $P(rad)/M(Sun)$ is $P(rad)(M(Sun)) \sim .510^{12}/y$. The estimate for $P(wind)/M(Sun)$ is $x \times 10^{-14}/y$, x in the range $[2,3]$. The ratio R is in the range $[25,16.7]$.

For the M_{89} model, the solar wind could be created by the transformation of M_{89} nucleons to M_{107} nucleons. This process is new from the standard physics view.

1. If the process occurs as a single step $k = 89 \rightarrow 107$, the energy of the ordinary nuclei is huge and their velocity is essentially light velocity. This cannot make sense.

   In the model for Centauro and Gemini events p-adic cooling allows to avoid this [K4, K5, K6]. p-Adic prime $p \simeq 2^k$ would correspond a temperature in p-adic thermodynamics which is for mass squared rather than energy and mass scale would be indeed given by $m(k)$ which would gradually reduces in the cooling.

   In the p-adic cooling, the p-adic length scale of the nucleon would be increased in a stepwise manner octave by octave: $L(89) \rightarrow L(91) = L_(93)/2 \rightarrow ....L(107)$. 9 steps would be involved. Mass scale would be reduced in the same way. Whether particles can appear with several p-adic mass scales has been a long standing question and it might be that solar physics demonstrates this!

   The p-adic cooling would produce final state nuclei which do not move with light-velocity since the energy of about $m(89) = 511m(107)$ would be transformed to photons and mesons of various hadronic physics along the path and eventually give rise to radiation.

2. A given step would involve transformation $N(k) \rightarrow N(k+2)$ of a nucleon given mass m to that with mass $m/2$ and emission of some particle say photon or meson of the physics associated with p-adic length scale $L(k-2)$. These particles of at least part of them would heat the solar surface producing the radiation from the Sun.

   The gamma rays produced at the first step of the process have so high energy that they are not expected to thermalize to thermal radiation at the surface of the Sun but leak out of the Sun. These gamma rays would belong to the anomalous gamma rays from the Sun. The absence of anomalys gamma rays in the range 30-50 GeV suggests that meson production dominates over the production of gamma rays in the transformation $N(k) \rightarrow N(k+2)$. Therefore the spectrum of gamma rays should reflect the mass spectra for the pions of the hadron physics appearing in the casca coming as powers $2^{107-k}m(\pi)$.

3. Consider the kinematics for the first step of the p-adic cooling in which one has $k = 89 \rightarrow k+2 = 91$. Assume that the transition is $N(k) \rightarrow N(k+2) + X$. Assume for definiteness that X has so small mass that it can be regarded as massless. Energy conservation gives $E(107) = m_(89) - E_X$, $E(X) \simeq p(X)$ and mass shell condition for the $k = 91$ nucleon gives $E(X) = 3m(89)/8$ from this one obtains for the velocity of the nucleon $\beta = v/c = 3/8$.

4. At each step the same occurs and from the formula $\beta = \beta_1\beta_2/\beta_1 + \beta_2$ for the addition of velocities, one obtains that v is scaled down by a factor 1/2 at each step. 9 steps gives for the velocity of $N(107)$ the value $\beta(107) = 3/8 \times 2^{-9} = 3 \times 2^{-12} \simeq 3/8 \times 10^{-3} \sim 10^5$ m/s. The velocity is non-relativistic and corresponds to a kinetic energy $m_n\beta^2/2 \sim .5$ keV.

   The temperature of the solar corona is $\sim .1$ keV and the heating of the solar temperature could be caused by the dissipation of the energy of nucleons. This energy is also near the energy scale of dark nucleons in the model of "cold fusion" as dark fusion.

The high energy gamma rays are not expected to thermalize and they would indeed contribute to the gamma ray anomaly. To estimate the thermal part of the energy flow one can assume that the gamma rays thermalize only for the steps $k \to k+2$ from $k \geq k_0$. This would mean that the mass $m(k)/2$ nuclei $N(k)$, $k \geq k_0$, $k_0 = 107 - r_0$ nuclei would be transformed to radiation. The mass transformed to radiation would be the $m(107) \times \sum_{r=0}^{r_0-1} 2^r = m(107)(1 + 2 + 2^2 + .. + 2^{r_0-1})$.

The ratio $R = P(rad)/P(wind)$ of the energy lost as radiation to the mass lost as solar wind would be in a rough approximation $R = 1 + 2 + 2^2 + .. + 2^{k_0-1}$. $k_0 = 101$ (prime) for which one has $m(101)/2 = 4m(107) = 4GeV$ gives $R = 30$ and $k_0 = 103$ with $m(103)/2 = 2m(107) = 2GeV$ gives $R = 22$. The ratio R is in the range $[25, 16.7]$ This favors the $k_0 = 103$ option.

To sum up, the completely crazy M_{89} option explains nicely the missing .5 percent of solar nuclear matter, the gamma ray anomalies, and the formation of planets as explosions of the surface layer. By baryon number conservation, the explosion of the surface layer would produce at most $3M_E$ of the ordinary nuclear matter. M_{89} nuclei can form atoms with the same spectrum as ordinary atoms and this would explain the strange findings of Moshina suggesting a rigid core for the Sun.

The energetics related to solar wind and radiation from the Sun would provide a killer test perhaps allowing us to choose between the two options. The ratio for the mass carried out by solar wind to the energy carried out by radiation should be consistent with the empirical findings.

The energy lost per year using solar mass as a unit is a convenient measure for the rate of the mass loss in solar wind and for the rate of the energy lost by radiation. In the standard model interpreted as thermal radiation at the surface of the Sun acting as blackbody radiation.

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3 The connection with the magnetic bubble hypothesis and application to solar anomalies

In this section a connection of the Sun with the magnetic bubble hypothesis [L19, L20] and some applications to solar anomalies are discussed.

3.1 A connection to the magnetic bubble hypothesis, Expanding Earth hypothesis, and the model for the formation of the Moon

In the TGD framework astrophysical objects co-move with the cosmic expansion but smooth expansion is not possible for them. This conforms with empirical facts. However, also astrophysical objects would expand but do this in rapid bursts identifiable as phase transitions of monopole flux tubes increasing their thickness and liberating energy since their string tension is reduced [L22, L26, L27].

This view has a more concrete description.

1. Magnetic bubble is a layer of matter associated with a tangential network of monopole flux tubes. Explosions throwing out magnetic bubbles is the basic element of TGD basic view of the birth of various astrophysical objects, in particular planets [L19, L20]. These spherical bubbles would have gravitationally collapsed to form planets.

   Also moons and planetary rings could have formed in the gravitational collapse of the magnetic bubbles. The assumption that the Moon was formed in the collapse of a magnetic bubble thrown out by the Earth about 4.5 billion years ago explains numerous anomalies associated with the physics of Moon [L24].

2. Baryon number conservation allows the transformation of say M_{89} nucleons to M_{107} nucleons by a stepwise p-adic cooling. Unfortunately, it is not possible to say anything about the rate of this process. If the M_{89} nucleons are gravitationally dark, the explosion and decay to ordinary M_{107} nuclei could preserve gravitational quantum coherence since Λ_{gr} does not depend on the mass of the particle so that the nucleons would have gravitational Compton length $\Lambda_{gr} = R_E/2$ for $\beta_0 = 2^{-11}$ in the final state. The explosion could involve the change $\beta_0 = 1 \rightarrow \beta_0 = 12^{-11}$ increasing the quantum size. This transition could occur also in sunspots having size $\Lambda_{gr} = R_E/2$ whereas $\beta_0 = 1$ would predict a size, which is by factor 2^{-11} smaller.

   In the transition leading from M_{89} nuclei with $h_{eff} = h$ to M_{107} nuclei, a huge binding energy should be liberated. The nuclear energy liberated in a direct $M_{89} \rightarrow M_{107}$ transition corresponds to the mass difference of the M_{89} and M_{107} nuclei would be huge since most of the mass about 512 GeV of M_{89} nuclei would be liberated. Therefore this transition most naturally corresponds to a sequence of expansions increasing the p-adic length scale by factor of 2 in a single step (of course, also smaller increments of p are in principle possible) so that the final state nuclein would have had reasonable kinetic energies and velocities. This energy burst would have thrown a magnetic bubble from the surface of the Sun and led to the generation of the planetary system [L19, L20]?

3. The transitions increasing the p-adic length scale by factor 2 could be very general and one might think that $p \sim 2^k$, gives to virtual BHs. I have proposed [K5, K6] that mysterious Centauro, Gemini, etc cosmic ray events correspond to a series of phase transitions increasing the p-adic length scale in this way. These ultrahigh energy cosmic rays would be hadrons of a scaled up hadron physics labelled by M_k or $M_{G,k}$, say M_{89}, which would decay to ordinary hadrons by a sequence of energy liberating phase transitions increasing the p-adic length scale by factor 2. Micro Big Bangs would be in question.

I have proposed that the Cambrian explosion, which occurred about 500 million years ago, corresponds to this kind of sudden burst [L4, L10, L18, L17]. The expansion of the radius by factor 2 requires a huge amount of energy: where could this energy come from?

1. It seems that a transition between different nuclear physics cannot be in question. Rather, a transition between different atomic physics could be involved.

2. One proposal is that the value of h_{eff} for ordinary matter increases from $h/2$ to h [L18, L17, L24]. The atomic binding energies are reduced in a good approximation by factor 1/2 radii increased by factor 2 and the liberated binding energy could compensate for the decrease of the gravitational binding energy. In this expansion the p-adic length scale characterizing Earth increased by factor 2.

The origin of the Moon is the mystery discussed in [L24, L20]. The TGD based proposal is that the Moon was formed in the explosion throwing out a magnetic bubble as a surface layer of Earth, which then suffered gravitational condensation to form the Moon. The basic challenge of this proposal is the identification of the energy source, which would compensate for the reduction of the gravitational binding energy and provide the needed kinetic energy needed to throw out the layer, which would have gravitationally condensed to form the Moon.

What comes into mind is dark nuclear fusion, which explains "cold fusion" and gives rise to the heating in the formation of protostars. This process would occur also in the solar corona. Could it take care of the energy needed to form the Moon?

1. The fraction of missing ordinary nuclear matter in the Sun is rather precisely .5 percent. Intriguingly, the mass of the Moon is 1.2 percent of the mass of the Earth. Is this a mere coincidence?

2. Did the layer of the Earth forming the Moon consist of closed very long monopole flux tubes connecting the pole regions of the Earth and carrying 1.2 per cent of the mass of Earth as very long dark nuclei and therefore analogous to the dark nuclei appearing in TGD inspired quantum biology and giving rise to a realization of the genetic code [L13]? The dark

nuclear binding energy would have been much smaller than the ordinary nuclear binding energy so that essentially the nuclear binding energy would be liberated in the process and give energy of order few MeV per nucleon.

3. Could a phase transition transforming these very long dark M_{107} nuclei to ordinary M_{107} nuclei have occurred? The liberated ordinary nuclear energy would have transformed to the kinetic energy and thrown this layer out so that it formed the Moon.

   The liberation of the nuclear binding energy would have given a velocity $\beta \sim \sqrt{2MeV/m_p} \sim 10^{-3}$ per nucleon. The needed velocity can be estimated from the escape velocity and to a kinetic energy $\beta^2/2 = GM_E/R_E$. This gives $\beta \sim 10^{-5}$, which corresponds to an energy about eV per nucleon. The change of the binding energy would be only a minor fraction of the liberated energy.

4. A more natural option is the same as in the case of Cambrian Explosion. The increase of the $h_{eff} = h/2 \rightarrow h$ for atoms liberated an energy, which is roughly atomic binding energy per atom and is measured using eV as a natural unit.

3.1.1 The formation of planets as mini bigbangs

According to the vision of [L19, L20], planets could have formed in an explosion of a surface layer of the Sun. The model for the missing nuclear mass suggests that this layer could have consisted of M_{89} monopole flux tubes.

1. The explosion of M_{89} layer would have been caused by the transformation of the layer to ordinary M_{107} baryons. This could have occurred in several steps through intermediate hadron physics labelled by $p \simeq 2^k$. The explosion would have liberated a huge amount of energy since the number of nucleons would have been preserved and thrown out (part of) the layer. The mass shell would have been like a rocket using nuclear mass as fuel.

   The explosion would create an expanding spherical layer of ordinary $M107$ nuclear matter, which could have gravitationally condensed to a proto planet since the monopole flux tubes making it a rigid sphere would split in the explosion.

2. Suppose M_{89} layer was a fraction x of the missing nuclear mass about $1500M_E$. This predicts the number of M_{89} baryons as $N_{89} = M_{layer}/m_{89} = .005M_{Sun}/m_{89}$. The number of M_{107} nucleons produced in the explosion would be the same and the corresponding M_{107} baryonic mass of the planet would be $M_{layer}/512 = x \times 3M_E$. If one half of the M_{89} mass is in the interior of the Sun as an analog of a dipole, the upper bound is $1.5M_E$.

3. Also the cores of outer planets could have emerged by this mechanism and the condensation of the matter from the environment could have created the gaseous envelope.

In the gravitational condensation a rigid spherical surface would transform to a planet at Bohr orbit describable by the Nottale's atomic model for the planetary system.

1. The angular momentum quantization condition for the rigid sphere would be replaced by the quantization condition for angular momentum as $L/M = nr_s/\beta_0$, $\beta_0 \simeq 2^{-11}$ plus Newton's law, which for the rigid sphere would correspond to the vanishing of torque guaranteed by the sphericality.

2. Angular momentum conservation poses strong constraints on the model, in particular on the orbital rotation frequency of the planet. One prediction is that the planets should preferentially rotate in the same counter clockwise direction as the Sun is spinning (this fact is not well understood). Only Venus and Uranus are exceptions to this rule and in the case of Venus it is thought that a collision with a fast moving asteroid has changed the rotation direction. One cannot of course exclude the possibility that the M_{89} layer of the Sun can also rotate in a direction opposite to that of the Sun.

3. A quantitative test is provided by checking whether the rotational angular momenta of the planets are nearly the same or by dissipation somewhat smaller than the angular momentum associated with the M_{89} layer. The prediction is

$$L_{layer,spin} = (2/3)M_{layer}R_{Sun}^2\Omega_{Sun} = L_{E,rot}M_E d_E^2 \Omega_{E,rot} \quad . \tag{3.1}$$

.

Substituting the numbers $M_{layer} = 1500M_E$, and $d_E = AU = 1.49 \times 10^8$ km, $T_{E,rot} = 365$ d, $T_{Sun} = 25$ day, one obtains $L_{layer}/L_{E,rot} = 1.11$. The discrepancy could be due to the dissipation.

This simple picture fails for the other planets.

1. For the circular orbits the Kepler's laws alone implies $L_P/L_E = (M_P/M_E)^{3/2}(R_P/R_E)^{1/2}$. Since the radii and masses of the giant planets are considerably larger than M_E, the angular momenta must be considerably larger than $3L_E$, which would be considerably larger that the upper for the momentum of M_{89} layer from the conservation of the angular momentum in the transformation of the exploded spherical layer to planet Earth.

   One can imagine that the explosion initiated the gravitational condensation of a rotating cloud around the radially expanding spherical layer and that this layer condensed to form the giant planet.

2. If baryon number and angular momentum are conserved in the transformation of a fraction x_P of the M_{89} layer to a planet or a seed of planet, one has $M_P/M_E = x_P = L_P/L_E$. One the other, one has $L_P/L_E = (M_P/M_E)^{3/2}(R_P/R_E)^{1/2}$. These conditions imply $M_P/M_E = R_E/R_P$, which does not make sense except in the case of the Earth. Certainly Earth is very special.

   (a) For Mars one has $M_M/M_E = .1$ and $R_E/R_M \simeq .25$ as predicted by the Bohr orbitology. This might make sense if the radius of Mars has increased from $.1R_E$ to $.25R_E$.

   (b) For Venus one has $M_V/M_E = 4/5$ and $R_E/R_V \simeq 5/4$. The discrepancy is not very large. The radius should have decreased from $R_E/R_V = 5/4$ to $R_V/R_E \simeq 4/5$ for which it can correspond to a Bohr orbit. Could Bohr quantization have forced the change of the radius and angular momentum. The opposite rotation direction of Venus could have been caused by a collision with an asteroid. The second option is that the rotation direction of M_{89} layer was opposite to that for the Sun.

       Maybe one could understand the reduction of the radius as being due to the Bohr quantization condition whose generalization is the key aspect of ZEOP. Indeed, the integers n in the condition $L = n\hbar_{gr}$ are rather small for $\beta_0 = 2^{-11}$. In a more realistic treatment there are also non-circular Bohr orbits and there is degeneracy with respect to the angular momentum quantum number. Could the decrease of the radius of an elliptical orbit have led to a circular orbit? This would have led to

   (c) For Mercury one has $M_{Me}/M_E = .055$ and $R_E/R_{Me} = 5/3$. One should have $M_{Me}/M_E = R_E/R_{Me}$ would give $R_{Me} \simeq 18R_E$. This does not satisfy the Bohr quantization condition for a circular orbit. The reduction of the radius of the Mercury by a factor 1/30 should have taken place. Again one can ask whether a highly elliptical orbit could have transformed to a nearly circular orbit in order to satisfy the Bohr quantization condition?

Star Vega provides support for the proposed general view of the formation of planets. The popular article with title "'Ridiculously smooth': James Webb telescope spies unusual pancake-like disk around nearby star Vega and scientists can't explain it" (see this) informs that James Webb telescope has found that star Vega probably has no planets.

Vega is a blueish colored star about twice as massive as the Sun and located at distance of about 25 light-years from Earth and is therefore rather near to Sun. By its large mass Vega is predicted to be short lived. Vega is .5 billion years old and considerably younger than Sun. The age of Sun and its planetary system, believed to have condensed simultaneously from a proto disk, is believed to be 4.6 billion years. Due to its fast spin, close proximity to Earth and the fact that its magnetic pole is pointed right at us, Vega appears very bright in the night sky. Vega is the fifth-brightest star visible from Earth to the naked eye in Northern sky ("Pohjan Tähti" in Finnish).

JWST images reveal that Vega is surrounded by a surprisingly smooth, 100 billion-mile-wide (161 billion kilometers) disk of cosmic dust similar to the similar disk believed to have surrounded Sun for 4.5 billion years ago, confirming that it is probably not surrounded by any exoplanets. The standard model for the formation of planets and Sun from this kind of disc however predicts that Vega should have planets. This might mean a death blow for the standard narrative of the formation of planets.

The TGD based model for the formation of planets predicts that planets were formed in mini bigbangs, that is explosions in which the parent star lost a surface layer consisting of closed flux monopole flux tubes flowing along the surfacein North-South direction. The surface layer hand roughly the mass of the planet to be formed and condensed later to the planet [L19, L20, L22].

The model is developed in more detail in [L25] and differs dramatically from the standard model view of the stellar energy production. Stellar wind and radiation would be produced at the surface layer consisting of nuclei of a scaled up variant of ordinary hadron physics predicted by the padic length scale hypothesis [K5, K6]. I refer to this hadron physics as $M_{89} = 2^{89} - 1$ hadron physics. M_{89} nuclei would have mass scale, which is 512 times that of the nucleo of ordinary hadron physics, which corresponds to $M_{207} = 2^{107} - 1$.

Whether the properties of Vega, for instance the fact that according to the standard theory it has lower abundances of elements heavier than ^{4}He, could explain why these mini bigbangs did not occur for Vega, remains an open question. This would require a more precise understanding of what causes these mini bigbangs. These explosions should have induced the decay of M_{89} hadrons to ordinary hadrons so that the entire flux tube layer would have exploded and decayed.

Could some kind of quantum critical phenomenon, stimulated by external perturbation, be in question? The TGD based stellar model predicts that stars have flux tube connections to other stars and also to the galactic blackhole-like object and this could make possible this kind of perturbations. Ordinary solar wind would correspond to similar local explosions. This suggests a similarity with the TGD based models for the sunspot cycle [L25] and for the geomagnetic reversals and excursions for which I have considered a model based on stochastic resonance [L23].

3.1.2 Supernovae as explosions of magnetic bubbles?

Could the explosions of either M_{89} magnetic bubbles induce supernovae? The following vision suggests itself.

1. The flux tubes as M_{89} super-nuclei split to ordinary M_{107} nuclei and produce ordinary nuclear matter and liberate energy. This transition would give an additional contribution to the nuclear matter outside stars. The decay of giant super nuclei defined by the monopole flux tubes would also create nuclei heavier than Fe, which are not produced in the stellar cores.

2. The pressure pulse created in this way could lead to the formation of supernovae and blackhole-like objects. Various giant stars could be the outcome of these kinds of explosions of the M_{89} surface layer?

One can check whether this hypothesis might make sense in the case of supernovae. I attach here a piece of text from the Wikipedia article about supernovae (see this) almost as such.

1. A supernova occurs during the last evolutionary stages of a massive star, or when a white dwarf is triggered into a runaway nuclear fusion. The original object, progenitor, either collapses to a neutron star or black hole, or is completely destroyed to form a diffuse nebula. The peak optical luminosity of a supernova can be comparable to that of an entire galaxy before fading over several weeks or months.

2. Theoretical studies indicate that most supernovae are triggered by one of two basic mechanisms: the sudden re-ignition of nuclear fusion in a white dwarf, or the sudden gravitational collapse of a massive star's core.

3. In the re-ignition of a white dwarf, the object's temperature is raised enough to trigger runaway nuclear fusion, completely disrupting the star. Possible causes are an accumulation of material from a binary companion through accretion, or by a stellar merger.

4. In the case of a massive star's sudden implosion, the core of a massive star will undergo sudden collapse once it is unable to produce sufficient energy from fusion to counteract the star's own gravity, which must happen once the star begins fusing iron, but may happen during an earlier stage of metal fusion.

5. Supernovae can expel several solar masses of material at speeds up to several percent of the speed of light. This drives an expanding shock wave into the surrounding interstellar medium, sweeping up an expanding shell of gas and dust observed as a supernova remnant. Supernovae are a major source of elements in the interstellar medium from oxygen to rubidium. The expanding shock waves of supernovae can trigger the formation of new stars. Supernovae are a major source of cosmic rays. They might also produce gravitational waves.

These facts suggest that both in the case of white dwarfs and massive stars, the transformation of M_{89} super-nuclei to ordinary nuclei triggers the supernova by creating a powerful pressure pulse towards the core of the star.

In the case of a supernova, the mass thrown out is measured using solar mass M_{Sun} as a unit. For the explosions producing planets, the mass M_E of the Earth is the natural mass unit. Can one understand this?

1. In the case of the Sun the magnetic bubble would consist of M_{89} monopole flux tubes forming a mass of about $.005M_{Sun}$. The baryons produced in the $M_{89} \rightarrow M_{107}$ transition make a total mass of about $3ME$ at most and would compensate for the missing nuclear mass inside the star.

2. A good guess is that the model for the solar magnetic bubble generalizes as such so that the fraction of the mass of the magnetic bubble mass scales like $(R_{star}/R_{Sun})^2$. For blue giants (see), the masses are in the range $10-300$ M_{Sun} and the radii vary in the range $10-100R_E$ as the table of the Wikipedia article shows. The amount of ordinary baryons produced would be in the range 10^2-10^4 M_E at most and considerably smaller than $M_{Sun} \sim 10^6 M_E$.

3. In accordance with the expectations, the explosion should also throw out a considerable amount of ordinary nuclear matter. The huge inward directed pressure pulse produced by the transformation of the M_{89} layer to M_{107} nuclear matter would produce as a reaction a strong inward pulse and this in turn would induce an outward pulse throwing the ordinary nuclear matter out.

4. In the case of white dwarf the inward directed pressure pulse could heat the core and re-ignite a runaway nuclear fusion inducing a total disruption of the white dwarf. In the case of a massive star this could induce a gravitational collapse of the core leading to a blackhole-like object or a neutron star.

To sum up, the TGD based model would solve the problem due to the missing nuclear mass and provide a missing link to the model of supernova. The decay of the giant M_{89} nuclei to ordinary nuclei would also explain the origin of the nuclei heavier than Fe. One could understand the solar wind in terms of local explosions due to a splitting of closed flux loops for which M_{89} nucleons transform to M_{107} nucleons and the liberated energy throws the loop out of the Sun.

3.2 Application to some solar anomalies

The physics of the Sun involves many poorly understood aspects suggesting that the view about the role of the solar interior might be wrong and the surface of the Sun might be the key player of the solar dynamics. The reversal of the polarity of the magnetic field of the Earth is not well-understood; the flux of solar neutrinos and the rate of convective heat transfer are anomalously low; the shape of the Sun is not affected by the solar cycle variability. These anomalies are discussed in what follows.

3.2.1 Reconnections and the reversal of the magnetic polarization

There reversal of the solar magnetic field occurring with an 11 year period is one of the poorly understood aspects of the Sun and I have proposed a model for this process [L20].

1. Reconnection makes possible the orientation reversal of the solar magnetic field. The portions of the monopole flux with opposite directions must be near to each other and touch so that the splitting to closed monopole flux tubes becomes possible. These short flux tubes can change their orientation and after that fuse back to the flux tubes with opposite direction of the magnetic flux. The polarization reversal could involve to subsequent time reversals ("big" state function reductions). The polarization reversal could involve to subsequent time reversals (big state function reductions).

   Here near means that the distance of the flux tubes is smaller than $R_E/2$, where R_E is the Earth radius. Note however that the density of M_{89} nucleons is 1 per ordinary M_{89} Compton area(!) whereas in the vertical direction the M_{89} nucleus takes a distance $R_E/2$: a kind of supra phase with very large horizontal quantum overlap is in question.

2. In the TGD inspired quantum biology, biocatalysis involves a reduction of h_{eff} for U-shaped flux look connecting the reactants. This reduces the length of the flux tube and brings reactants together and liberates energy kicking the reactants over the energy wall preventing the reaction otherwise.

   Now something analogous could take place. The closed flux tube having a distance of about $R_E/2$ between parallel strands with opposite polarities could suffer a phase transition reducing the value of $\hbar_{gr}$ so that their distance would become very small and the reconnection splitting the long and narrow flux tube pair to pieces which then reconnect to form a narrow structure with opposite polarization. After that h_{eff} would increase to $\hbar_{gr}$.

3. The twisting of the rotating flux tubes at the surface of the Sun eventually leads to a reconnection process splitting the flux tubes into short pieces. The twisting requires that the second end, say the end at the magnetic North pole is fixed. This can be understood if a bundle of flux tubes arrives from somewhere, say the galactic nucleus, and turns back near the South pole and returns so that U-shaped flux tubes are obtained. The flux tubes would bring M_{89} nuclei as a fuel needed because they decay to ordinary nuclei at the surface.

   This bundle cannot get twisted so that twisting occurs at the surface of the Sun and eventually leads to a situation in which the flux tubes touch each other and a series of reconnections splitting them into pieces and giving rise to sunspots takes place. The day of the Sun is 25 . *resp.* 36 Earth days at the equator . *resp.* poles. 11 year period corresponds to about 117 . *resp.* 112 full rotations at equator . *resp.* poles. During this period the metabolic energy feed stops and the solar activity is indeed reduced at the sunspot maximum.

3.2.2 The mystery of the solar corona

The solar corona is a mystery from the point of view of standard solar physics. Something accelerates the particles emerging from the surface. One should understand the acceleration mechanism and explain why the solar corona is there and why it has such a high temperature.

This predicts the acceleration mechanism. The local transformation of M_{89} nucleons to M_{107} nucleons to ordinary nucleons liberates the needed energy. The recoil momentum would create solar flares known to challenge momentum conservation in the standard framework. This would create a solar wind consisting of ordinary nucleons.

The high temperature of the solar corona could be due to the liberated energy. Could the dark M_{89} nuclei at the surface layer of the Sun transform to ordinary nuclei with maximal energy predicted by the p-adic cooling. They would heat the solar corona to a temperature of about .1 keV below which is lower than the binding energy scale for the dark M_{107} nuclei with $h_{eff}/h = 2^{10}$ so that they would be thermally stable. The solar wind could consist of dark nuclei, which decay spontaneously to ordinary nuclei.

3.2.3 The problems related to the solar convection and solar neutrinos

The solar convection problem [E19], briefly discussed in the introduction, means that the convection, which should bring nuclear matter from the core to the surface, is much smaller than believed to be. The solar neutrino problem means that the solar neutrino flux is much lower than it is predicted to be. Furthermore, there is a correlation of the neutrino flux with the solar wind and anticorrelation with sunspot number were discussed [E1, E21]. These findings do not conform with the view that nuclear fusion produces the nuclear matter arriving from the Sun, which is then transferred to the surface by convection.

I have already earlier [L22] asked whether the Sun could be satisfactorily described by using the analog of the shell model with the harmonic oscillator potential replaced with gravitational potential associated with the average mass density of the Sun.

The basic prediction concerning neutrinos would be that, not only nuclei, but also neutrinos are predominantly produced at or near the surface layer of the Sun: there would be no nuclear fusion in the core of the Sun! The long M_{89} flux tubes split by reconnection to short loops M_{107} nuclei and the liberated energy transforms to kinetic energy causing the explosion. This process would also produce neutrinos brought to Earth by the solar wind.

Neutrino mixing is a well-established phenomenon and would take place also now. However, the model for the production of neutrinos changes profoundly. One expects that all neutrino generations can be produced in the $M_{89} \rightarrow M_{107}$ transition. The challenge is to predict the rate of the neutrino production for this option. The rate would depend on the fractions of weakly decaying ordinary nuclei produces in the p-adic cooling.

The production of neutrinos in the decays of ordinary pions produced as end products $M_{89} \rightarrow M_{107}$ transition could also be an important mechanism, analogous to the interaction of the solar surface and atmosphere with cosmic rays also proposed as a mechanism for the production of neutrinos.

Mikheyev-Smirnov-Wolfenstein (MSW) effect (see `https://en.wikipedia.org/wiki/Mikheyev\OT1\textendashSmirnov\OT1\textendashWolfenstein_effect`this) is proposed as an explanation for the anomalously large mixing of high energy neutrinos involves a resonance effect caused by the presence of a density of electrons with a value dictated by neutrino mass difference considered. The MSW effect might not be needed in the TGD based model since the M_{89} contribution could be decisive. If dark fusion prevails in the solar core, the production of neutrinos in beta decays might neglilible.

M_{89} contribution could explain why the neutrino flux correlates with solar activity. What about anticorrelation with the number of sunspots? The TGD based model for the reversal of the solar magnetic field assumes that the monopole flux tubes at the surface of the Sun split to short loops by reconnections, which then change their direction from North-South to South-North. The splitting would occur at sunspots. During this period there would be no big loops, whose reconnection and the transformation to ordinary nuclei would generate the solar wind. If the M_{89} nuclei do not transform to ordinary nuclei during this period, the neutrino flux would have a minimum.

3.2.4 Why is the shape of the Sun not affected by solar cycle variability?

In the Scitechdaily article (see this) an interesting question, motivated by the article of Kuhn et al published in Science Express [E22] was posed. How is it possible that the solar radius is not affected by solar cycle variability? This is one of the many questions which are popping as the existing view of solar physics is collapsing. The early cosmology and galactic physics collapsed first and now stellar physics is following!

TGD provides a possible answer.

1. The numerous anomalies of the Sun leave only one conclusion: the standard view of the solar interior is very probably wrong. Only the activities of the M_{89} surface layer, magnetic bubble, is active and generates solar wind and thermal radiation and the anomalous gamma ray spectrum.

2. The solar wind consists of matter emerging from the magnetic bubble forming a thin layer at the surface of the Sun. Solar convection rate is anomalously low so that the nuclei of the solar wind from the Sun do not arrive from the solar core as fusion products but are

created in a phase transition in which M_{89} nucleons at long monopole flux tubes transform to ordinary nucleons and liberate their nuclear binding energy or almost all of their mass as kinetic energy and bosonic matter. These flux tubes form what I have called a magnetic bubble at the surface of the Sun. Solar core where fusion would be occurring could be a mere fragment of imagination.

3. One can argue that in a good approximation Sun is analogous to a quantum gravitational harmonic oscillator consisting of mass shells as magnetic bubbles and rigid spherical layers with radii predicted by harmonic oscillator model. The analogy with atoms and nuclei is obvious: only the valence shells are active and interact with the external world whereas the inner shells, where the ordinary fusion occurs, look totally silent! This kind of layered structure was one of the first suggestions of classical TGD about 40 years ago but I could not take it seriously.

4. Planets and supernovae correspond to massive explosions throwing out the outermost M_{89} shell and solar wind would be caused by their local explosions.

This allows us to answer the question posed in the beginning. Only the solar wind generated at the solar surface affects the corona. The interior of the Sun has very small effects on the shape of the Sun since apart from ordinary fusion it is totally passive just like the inner shells of the atom and the products of nuclear fusion, occurring at the mass shells with the required mass density, remain inside the solar core. Astrophysics would be extremely simple.

4 Further questions

The development of a completely new idea is not a rational process. Only when the smoke clears, one realizes what questions one should have posed first in order to avoid side tracks. Here is the list of these kinds of questions at this time.

I started from the idea that the surface of the Sun involves a monopole flux tube layer carrying M_{89} nucleons having mass 512 times that of ordinary nucleons. This would explain the missing nuclear matter of the Sun, the evidence for solid structures at the surface of the Sun, and gamma ray anomalies. The decay of M_{89} nuclei would give rise to ordinary nucleons of the solar wind and generate the radiation from the Sun. If the original goal had been to construct a model of the Sun, I would have started with the following questions.

1. Can one really give up standard nuclear physics and reduce the nuclear physics of the Sun to what happens in the M_{89} flux tube layer? If this were the case, one should start from scratch and the entire known nuclear physics of the Sun should be rediscovered.

   The natural possibility is that the M_{89} surface layer determines what is seen by the observer during the life cycle of the star. Only after the supernova explosion or a formation of BH, the evolution inside the core of the Sun becomes in daylight via the abundances of the elements created. The anomalously low convection currents in the convection zone support this view. Also the puzzle caused by elements heavier than Fe finds a solution: they would be produced in the decay of M_{89} nuclei at the surface.

   It seems that the TGD counterpart for ordinary nuclear physics must be present in the core of the Sun. Could the monopole flux tubes containing only M_{89} nucleons take care of the transfer of the nuclei and energy from the Sun to the environment? This process would involve the decay of M_{89} nuclei to the ordinary nuclei. The M_{89} layer would be an addition to the nuclear physics of the Sun rather than its replacement.

2. How to achieve consistency with the model based on dark fusion? I have developed rather nice models of the "cold fusion" and pre-stellar evolution igniting the ordinary fusion. This suggests that the convective zone corresponds to the region where the dark fusion prevails and the temperature gradually rises as one approaches the core, where the ordinary fusion is ignited. Note that the decay of the M_{89} layer to ordinary nucleons would also provide energy by helping to maintain the temperature in the convective zone.

3. What could be the thickness of the M_{89} layer? The Compton length of the M_{89} nucleon is a fraction 1/512 of the Compton length of the ordinary nucleon and ridiculously short. On the other hand, if one assumes that the density of dark M_{89} nuclei corresponds to roughly one per ordinary M_{89} Compton volume, one can understand the missing nuclear mass of $1500M_E$. Could gravitational Compton length, which does not depend on the mass of the particle, determine the thickness of the M_{89} layer? For the Sun with $\beta_0 = 2^{-11}$ it would be $\Lambda_{gr} = R_E/2$, where $R_E = R_{Sun}/109$ is the Earth radius defining also the size scale of the Sunspots. For $\beta_0 = 1$ it would be by a factor 1/2000 shorter. It turns out that the gravitational oscillator model predicts $\Lambda_{gr} = R_E/2$ as the basic length scale of the gravitational harmonic oscillator!

4.1 Could the solar core consist of dark nuclei?

An additional input is provided by the model for dark nucleons applied in the models of "cold fusion" [L2] and pre-stellar evolution [L7].

1. The earlier proposal [L7] was that the heating by the dark fusion would ignite the ordinary nuclear reactions giving rise to the stellar core. The convective zone could consist of dark nuclei and the core of ordinary nuclei so that the ordinary nuclear fusion would be a part of the model. Only after the supernova explosion, would the outcome of the nuclear fusion emerge into daylight.

   If the p-adic cooling generates solar wind and the radiation from the Sun, the ordinary fusion is not needed to explain them. Is there any need for the hot fusion in the solar core?

2. Also the solar neutrino problem challenges this picture! Mikheyev-Smirnov-Wolfenstein (MSW) effect (see `https://en.wikipedia.org/wiki/MikheyevSmirnovWolfenstein_effect`this), proposed as an explanation for the anomalously large mixing of high energy neutrinos, involves a resonance effect caused by the presence of a density of electrons with a value dictated by neutrino mass difference considered. The MSW effect might not be needed in the TGD based model since the M_{89} contribution could be decisive. A further anomaly is that the neutrino flux correlates with the solar wind and anticorrelates with the sunspot activity!

3. A much more radical possibility, suggested by the proposal that the Sun is analogous to atomic nucleus, is that dark nuclear fusion also applies in the core and the temperature of the core is of order 10 keV guaranteeing quantum criticality needed for the optimal dark fusion explaining the "cold fusion".

4.2 How M_{89} nuclei could be regenerated?

The birth of a new star requires the emergence of a M_{89} layer. This layer must be also regenerated after its decay. There might be also M_{89} nucleus deep in the interior of the Sun playing the role of the dipole of a dipole magnetic field. How could it emerge? The M_{89} nuclei must be generated in the solar nucleus or feeded from outside to the M_{89} layer. This allows us to consider two alternative identifications for the energy feed needed to regenerate M_{89} nuclei.

1. Time reversal could make it possible to extract energy from the environment of the solar nucleus to transform M_{107} nuclei to M_{89}. The needed energies are huge and it is far from clear whether these energies can be provided by ordinary nuclear reactions with a much smaller energy scale. If this were the case, the energy would come from the solar core and generate a heat current towards the boundary.

2. The energy arrives at the solar nucleus from the outside. TGD predicts that the stars of the galaxies form a network connected by monopole flux tubes [L21]. Could this network, acting like blood circulation, feed M_{89} nuclei from, say galactic nuclei, to the Sun, where they would be used as a fuel. M_{89} nuclei would be burned to M_{107} nuclei and in this process induce p-adic heating of the environment around the region at which they enter. This region could be either the M_{89} layer or the solar nucleus. The simplest option that it is the the M_{89} layer.

One can consider the first option in more detail although it seems that the second option is more plausible.

1. p-Adic cooling, occurring in a stepwise manner by reducing the p-adic scales by octaves, provided a model for the decay of M_{89} nuclei to M_{107} nuclei. Can one consider p-adic heating of M_{107} nuclei to M_{89} nuclei? There is evidence from LHC for the creation of M_{89} mesons and the solar gamma ray anomalies suggest that M_{89} and even $M_{G,79}$ mesons are produced. From this there is however a long way to the p-adic heating of nuclei increasing their mass by factor 512 but one can ask whether the p-adic heating leads in a stepwise way also to a formation of M_{89} nuclei.

2. In zero energy ontology (ZEO) [K11] it is natural to ask whether the p-adic heating could be a time reversal of the p-adic cooling identifiable as a quantum tunnelling involving a pair of "big" state function reductions (BSFRs). Huge energies are needed but the rise of the temperature could take place by steps proceeding hadron physics by hadronic physics with decreasing p-adic length scale $L(107) \rightarrow L(105) = 2L107.... \rightarrow L(89)$.

3. Time reversal and macroscopic quantum coherence are general aspects of TGD, and one can wonder whether heating quite generally involves a time reversal. In the TGD based model of self-organization the energy feed could correspond to extraction of energy from the environment by using reversal of the arrow of time.

4. Could the solar core involve a hierarchy of layers for which the p-adic temperature increases in powers of 2, at least up to the QCD $\Lambda \sim 100-200$ MeV assignable to the the temperature at which the transition to quark gluon plasma is believed to occur in QCD?

   This proposal would be a diametric opposite of the suggestion that solar core is at a relatively low temperature and dark fusion implies the analog of genetic evolution.

4.3 Analogies with the TGD inspired quantum biology

There are strong analogies with the TGD inspired quantum biology.

1. In the TGD inspired quantum biology the dark variants of ordinary nuclei provide a fundamental realization of the genetic code in terms of dark nuclei and this might be possible also for the M_{89} case. Note that the genetic code has a universal realization as a completely exceptional icosa tetrahedral tessellation of the hyperbolic 3-space H^3 (mass shell or light-cone proper time= constant surface) [L13] allowing as building bricks tetrahedra, octahedra, and icosahedra rather than than only a single platonic solid. Realization is also possible in all scales.

2. Could the cosmic network of monopole flux tubes connected to a galactic blackhole-like object be analogous to a living organism? The filamentary structure observed in the cosmic scales strongly brings in mind the connective structure of the brain and could be associated with the monopole flux tube network.

3. M_{89} layer is responsible for the solar wind and radiation from the Sun. What unavoidably comes to mind that M_{89} layer is like the cell membrane, which acts as a sensory organ and excretes the outcome of the M_{89} catabolism as solar wind and surplus energy as solar radiation.

4. What about the convective zone and solar core? If the abundances of the matter outside the stars are determined to a high degree by M_{89} physics at the surface layer, the standard view of the solar core becomes a mere narrative challenged by the anomalously low convective heat transfer and the anomalously low neutrino flux from the core.

In the quantum model of the Sun, the solar core could be practically isolated from the external world. The heat flow could be from the surface layer to the interior and serve as a metabolic energy feed.

1. Could the decay of M_{89} nuclei provide metabolic energy for some processes in the convective zone possibly consisting of dark nuclei and in the solar core? If so, the energy transfer could be from the surface to the interior rather than vice versa as in the standard model!

2. If the core as a quantum system is analogous to an atomic nucleus, with the counterparts of spherical mass shells characterized by a huge gravitational Planck constant, as proposed in the gravitational harmonic oscillator model to be discussed, one can ask whether the ordinary nuclear fusion occurs at all in the core and whether the temperature of the solar core what it is believed to be.

   Could the hot nuclear fusion be replaced with dark fusion for a quantum critical nuclear matter explaining the scorned "cold fusion"? Could the temperature correspond to a critical temperature for dark fusion measured using 10 keV as a natural unit?

3. Could the solar core be analogous to the cell nucleus carrying the genome? This couldn't be farther away from the standard picture, which is however a purely theoretical narrative. Could the dynamics inside the core be reinterpreted as a self-organization of the nuclei to heavier ones representing the counterparts of genes in the TGD inspired quantum biology. Could the isolated solar core contain an analog to a cell nucleus carrying the genome as an M_{107} realization of the genetic code realized also in living matter where water plays the key role?

   Could neutron stars and blackhole-like objects represent the outcome of a genetic evolution.

4.4 How do the incoming M_{89} flux tubes interact with the M_{89} layer of the Sun?

The quantum biological analogy allows us to imagine how the M_{89} monopole flux tubes arriving at the Sun look like and interact with the M_{89} layer of the Sun.

1. In TGD inspired quantum biology flux tubes act as U-shaped tentacles and their reconnections for two systems builds bridges along which communications and matter transfer can take place. In the TGD inspired biology, these tentacles are an essential element of biocatalysis and of functioning of the immune system [K2]. Microtubules are highly dynamical systems and could be associated with U-shaped flux tubes whose lengths vary.

2. The dark variants of the ordinary nuclei provide a fundamental realization of the genetic code in terms of dark nuclei and icosa tetrahedral tessellation also for M_{89} nucleons.

Consider now a model for the interaction of the incoming M_{89} flux tubes with those at the surface of the Sun.

1. Imagine that a bundle of M_{89} monopole flux tubes arrives at the Sun from a blackhole-like entity in the center of the galaxy. The topology of the microtubule bundle gives some idea of what might be involved. Suppose that the arriving bundle forms a cylindrical bundle, which meets the surface of the Sun in a region near its magnetic North pole.

2. The structure could be highly dynamic in this region. Horizontal topological sum connections between the homologically non-trivial spheres could give rise to larger quantum coherent units from the flux tubes. In the extreme situation all the spheres could form a ring and one can say that flux effectively arrives along a cylindrical flux sheet. The degree of the locality of the interactions with the M_{89} layer depends on the longitudinal coherence.

3. Consider a situation in which the arriving flux tube turns back near the South Pole of the Sun to form a U-shaped flux tube (in a more complex option the flux tube can also pass the Sun). A reconnection of the U-shaped flux tube in the region near the North pole would split from it to a single closed flux tube of the M_{89} layer. This splitting would occur for the most arriving flux tubes.

   The M^{89} matter lost in the p-adic cooling to M_{107} matter could be regenerated by reconnecting the closed flux tubes of the layer to the arriving flux tubes feeding M^{89} matter.

What could be the quantum thickness of the M_{89} flux tube layer?

1. A natural looking assumption is that the flux tubes are dark, at least inside the Sun and perhaps also before arriving and leaving the Sun. The values of the effective Planck constants need not be the same however.

2. The Compton length of the M_{89} nucleon is a fraction 1/512 of the Compton length of the ordinary nucleon and ridiculously short. On the other hand, if one assumes that the density of dark M_{89} nuclei corresponds to roughly one per ordinary M_{89} Compton area (!), one can understand the missing nuclear mass of $1500M_E$.

   Could the gravitational Compton length, which does not depend on the mass of the particle, determine the thickness of the M_{89} layer. For the Sun, assuming $\beta_0 = 2^{-11}$, it would be $\Lambda_{gr} = R_E/2$, where $R_E = R_{Sun}/109$ is the Earth radius defining also the size scale of the Sunspots. For $\beta_0 = 1$ it would be by a factor 1/2000 shorter. It turns out that the gravitational oscillator model predicts $\Lambda_{gr} = R_E/2$ as the basic length scale of the gravitational harmonic oscillator!

Is it possible to speak of M_{89} genome and its evolution?

1. The decay of M_{89} flux tubes to short closed flux tubes by reconnection and further decay to ordinary nucleons determines the abundances of the solar wind. The arriving M_{89} flux tube defines a huge super-nucleus. Could this super nucleus decomposes to shorter M_{89} nuclei, analogous to the dark variants of genes and proteins of the TGD inspired quantum biology. If this decomposition determines the abundances of the solar wind, which in turn determines the spectrum of the star, the spectrum would reflect the M_{89} genome? Note also that the M_{89} atoms at the surface of the Sun have the same spectrum as M_{107} atoms.

2. Is the decomposition to M_{89} nuclei dynamical and subject to evolution in the same way as the ordinary genome? What inspired this question was the anomalous abundance of Lithium for a red dwarf with size 30 times the size of the Sun located in the Milky Way halo. The star is very metal poor and has Li abundance 10^5 times higher than expected [E13] (see this.

4.5 Could the thermodynamic model of the Sun and planets be replaced with a geometric description?

A basic objection against the quantum model of stars and planets is that thermodynamic notions like pressure are absolutely essential for the understanding of the physics of the solar and planetary interiors.

1. In the thermal models pressure prevents gravitational collapse. In the geometric model, the tension of the monopole flux tubes in vertical and horizontal directions would prevent gravitational collapse. I have developed a model of nuclei *resp.* atoms based on spherical structures carrying Platonic solids [L15] having nucleons *resp.* electrons at their vertices. If this applies also to the Sun and planets, they would resemble outcomes of engineering.

2. In the standard model, when nuclear fusion does not anymore produce enough energy, the pressure disappears and the core collapses. The counterpart of this description in the geometric model would be as follows. The monopole flux tubes and the dark matter at them require energy feed and nuclear reactions: otherwise the value of h_{eff} is reduced and the flux tubes shorten. The p-adic cooling of M_{89} nuclei could provide it. In the absence of the energy feed the flux tubes collapse and gravitational collapse is the outcome.

3. In standard physics, blackholes or neutron stars emerge in the death of the star due to the loss of the pressure created by nuclear reactions. In the absence of supporting flux tubes, the ordinary BHs correspond to volume filling M_{107} flux tube spaghettis. TGD suggests an entire hierarchy of BHs labelled by Mersenne primes and their Gaussian counterparts. Note that the p-adic cooling in the absence of nuclear reactions transforms M_{89} nuclei to ordinary nuclei and would lead to M_{107} BH. M_{89} blackholes could in turn emerge from $M_{G,79}$ blackholes.

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