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 fact that the mass of the Sun and the mass which is 4/3 times the mass of the Earth belong to this spectrum, puts bells ringing.

It however turned out that the TGD based model for the missing nuclear matter assigns the gamma ray anomalies to a magnetic bubble as a layer covering the surface of the Sun and consisting of closed monopole flux tube loops running in North-South direction. They could carry either M_{89} nucleons with a mass which is 512 times the mass of the ordinary nucleon (Option I) or dark variants of the ordinary M_{107} nucleons (Option II). This structure could be seen as a 2-D surface variant of the TGD counterpart of blackhole and under rather natural assumptions its mass is the missing 1500 Earth masses of ordinary nuclear matter. This model conforms with the earlier model of the sunspot activity related to the reversal of the solar magnetic field.

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. For Option I (II), this process would correspond to the touching of the M_{89} (dark M_{107}) flux tubes, whose distance would be larger than 2 Compton lengths of M_{89} (M_{107}) nucleons. The study of the energetics selects the totally crazy looking option Option I: for option II the radiation emitted by the Sun would be quite too small.

The model leads also to a proposal for the generation of the inner planets and Mars via explosion of the outer layer of the Sun consisting of M_{89} nuclei (dark M_{107} nuclei) to M_{107} nuclei. For 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. During the stellar evolution, the star would gradually lose its shells.

Contents

1 Introduction

This article was inspired by the article "Is the Sun a Black Hole?" by Nassim Haramein [E19] (see). 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, L23].

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, E26, E16, 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 [E14] 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, E24, E19] 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 [E25] and in [E15] 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 however by an order of magnitude lower than the ignition temperature for nuclear fusion. However, 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 would give rise to proto-stars and could explain the origin of nuclei heavier than Fe.

1.1.3 The TeV Sun

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The Quanta Magazine article "The Sun is stranger than the astrophysicists imagined" (see) 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 [E14, E13, 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 [E22]. This anomaly was not mentioned by Haramein but I have discussed it years ago from the TGD point of view [K7].

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 [E22] 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 [E23]. 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 $n_{ph} \sim .32 n_{atm}$ giving $p_{ph} \sim 6.4 p_{atm}$. 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 [E19]. 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 [E18].

   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 [E13] 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 [E19] 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, E20]. It is however argued that the anticorrelation with the sunspot number does not exist [E17]. 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

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, the construction of the model to a model of BHs predicting their mass spectrum.

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? This option does not look plausible.

This leads to two options.

Option I: The anomalous gamma rays below 35 GeV range suggest 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 mass about $1500M_E$ would be naturally associated with this kind of layer. The gamma radiation in TeV range requires a generation of M_{79} phase for which pion decays would produce gammas in TeV range. The transformation of M_{89} nuclei to ordinary nuclei liberates a huge, possibly too huge, energy. There are indications for both M_{89} and M_{79} mesons as bumps at LHC [K4, K5].

Option II: Monopole flux tubes contain dark M_{107} nuclei, whose decay to ordinary nuclei would give rise to "cold fusion" [L2, L9] liberating almost all ordinary nuclear binding energy. In this case the origin of all anomalous gamma rays would be due to the creation of M_{89} and M_{79} mesons.

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, L15].

Matter would be located at shells analogous to those in the nuclear shell model. The matter at the flux tubes could consist of M_{89} nuclei. If the average matter density is constant, the effective shells would correspond to harmonic oscillator orbitals.

In this framework, the outermost solar layer would be the analog of the outermost shell of atoms and determine the interactions with the external world. The explosions of the outer shells would create planets and solar wind would be created by local explosions of the outer shell. 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 [K7]. 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.

For **Option I** based on M_{89} nuclei, the radiation in the TeV range would require generation of M_{79} pions locally. For **Option II** based on dark M_{107} nuclei, also M_{89} pions would be generated locally.

Note that I have earlier considered gamma ray anomaly in the TGD framework [K7, K8] [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.

1.2.3 TGD based model for the missing nuclear mass

The finding of Asplund et al [E3, E26, E16, 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].

1. 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.

   M_k BHs 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}.

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.

2. The findings reported by Moshina [E22] 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 do the Options I and II relate to this finding?

   (a) **Option I** predicts closed M_{89} monopole flux tubes 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.

   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 [K4, K5].

   (b) **Option II** predicts that single layer of ordinary nuclear matter has mass of $2^{-18} \times 1500M_E \sim 4 \times 10^{-4}M_E$ and thickness of nucleon Compton length. 2^{18} layers of this kind is required and corresponds to a thickness of 2.5 Angstrom, which is atomic length scale. This brings in mind a neutron star. The nucleons should be however dark which reduces the binding energy.

   If one takes the TGD based model for the "cold fusion" as dark fusion seriously, the dark protons should have $h_{eff} \simeq 2^{10}$ and have a dark Compton length, which is roughly 1/2 of electron Compton length. This would give a further scaling by factor 2^{30} and the thickness of the layer would be about .25 m. The partial explosion of this layered structure could explain the formation of planets [L19, L20]. In the earlier view this phase was proposed to define a protostar but one can ask whether the entire Sun is analogous to a harmonic oscillator consisting of this kind of layers as geometric analogs of harmonic oscillator orbitals.

   (c) Is it possible to choose between these options? 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. For Option II, the predicted ratio would be larger than one so that it fails. Option I survives the test if the $M_{89} \rightarrow M_{107}$ transition corresponds to p-adic cooling [K4, K5] as an analog of period doubling occurring as a sequence of transitions in which the p-adic prime. $p \simeq 2^k$ 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. This would also explain the heating of solar corona being caused by the kinetic energy of M_{107} nuclei.

   (d) For Option II energy would be produced by "cold fusion" as the fusion of ordinary nucleons to dark nuclei, which then transform to ordinary nuclei. The earlier model suggests that dark fusion heats matter in protostars and leads to the ignition of ordinary fusion in the stellar core. The above argument suggests that this proposal must be given up. In the TGD inspired quantum biology, dark fusion is a basic mechanism and could also work outside the stars as an alternative mechanism of fusion.

3. The TGD based model for the Sunspot cycle [L20] suggests that the presence reflects the decay of closed monopole flux tubes parallel to the solar surface and slitting to short pieces by reconnection. These flux tubes could have one M_k nucleon per Compton length L_k just like the flux tube filling the M_k blackhole.

   The splitting of the flux tubes makes possible the change of the polarity of the magnetic field as a local process and after this the reconnections make it possible to rebuild the monopole magnetic field with an opposite polarity. There is no need for the TGD analogs of the ordinary BHs

   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 $R_E/2$!

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 [L23] 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] [K2].

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 [K4, K5]. 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 [K4, K5]. 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 $M/M_{Sun} \rightarrow 2^{-106}$. 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 $m(k)$.

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

   This gives for the radius of the system

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

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

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

giving

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

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

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

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 the Sun

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

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

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 Earth

The scaling $k = 107 \to 89$ gives

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

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 [K4] 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 [K4, K5] 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 [K4, K5]. 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 or dark M_{107} 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 $M = 1500 M_E$ 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 $1500 M_E$.

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_{107} nuclei create generate the anomalous gamma radiation from the Sun.

2.2.4 M_{61} hadron physics and Bohr radius

The scaling $k = 89 \to 61$ gives

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

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 $M_{G,k} = (1 + i)^k - 1$ [K4, L6, K9].

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, L23].

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 to 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]. It is is independent of the mass of particle in question (Equivalence Principle). Rather remarkably, in a good approximation one has $\Lambda_{gr}(Sun) = R_E/2$. Could $\Lambda_{gr}(Sun)$ define a lower bound for the size of the sunspots as quantum structures.

3. There is spectroscopic evidence [E22] 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 [K7]. 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 he spectra atoms with M_k nucleiwould 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 Option I: Are the nuclei at the monopole flux tubes M_{89} nuclei?

Dark M_{107} nuclei define the minimal option but since the M_{89} option was the first option that I considered, it is natural to discuss it first.

1. Sunspots and the high energy gamma radiation assignable to M_{89} nuclei could be associated with blobs of M_{89} nuclear matter at the surface of the Sun having resulting from the splitting of the monopole flux tubes to short close flux tubes by reconnction. 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. The fact that $k = 107$ BH has solar mass mildly suggests dark nuclei with $k = 107$ rather than $k = 89$ nuclei.

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.

3. The density of M_{89} nucleons should be maximal, just as in the collisions of the ordinary M_{107} nuclei believed in the QCD framework to generate the QCD plasma. There is evidence for this process from LHC [K4, K5]. Indeed, the monopole flux tubes carrying M^{89} nucleons are very near to each other and could touch. This could lead to the analog of the high energy nuclear collision and generate $M_{G,79}$ dark mesons decaying to TeV radiation.

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 $R_{Sun} = 109R_E \simeq 3.5 \times 10^8$, 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

$$M(M_{89}loop) = 2\pi y_{89}m_{89},$$

Here one has

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

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

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

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

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

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. One can avoid the overlap of the loops at high latitudes 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.

The basic objection agains this proposal is that the density at at the monopole flux tubes is so huge.

2.3.2 Option II: are the nucleons at the flux tubes 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 eV is the correct approach?

So: could one 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. This could be quite 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?

2. One should 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 [K4, K5]. 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, E26]. 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 (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]). To get the missing nuclear mass one should 2^{18+30} layers of thickness of L_e giving for the surface layer a thickness of .25 m.

   The dark nuclear binding energy is of order keV, which is about 10 times higher than the temperature at the solar corona.

4. Could the darkness of the atoms with dark M_{107} nuclei make them stable despite the high temperature of the solar surface?

2.3.3 Which option is correct?

There are two options for what the surface layers of the Sun could be.

For Option I, the totally crazy option, very long nuclei defined by monopole flux tubes formed from M_{89} nucleons with mass of about 512 GeV would be in question. The M_{89} nuclei could be also dark in the TGD sense and the explanation for the observations of LHC [K4, K5] is in terms of a creation of M_{89} mesons for which the value $h_{eff}/h = 512$ so that the dark M_{89} hadrons would have the same size as the ordinary hadrons. This would conform with the quantum criticality for the TGD analog of the phase transition interpreted in QCD as a formation of the quark gluon plasma.

Option I is completely crazy but it 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.

For Option II, the not so crazy option, dark variants of ordinary nuclei would populate the flux tubes. The dark M_{107} nuclei could appear in the solar corona also for the option I. For this one must give up the assumption that there is just a single layer if one wants to explain the missing nuclear matter of the Sun. The replacement $M_{89} \rightarrow M_{107}$ scales down the mass of the single layer by 2^{-18} and the increase $h \rightarrow h_{eff} = 2^{10}h$ reduces the mass of the layer by factor 2^{-20}. One must therefore have $2^{38} \sim 10^{12}/4$ dark layers with thickens of about 1/2 of the electron Compton length. The simple model for the formation of planets is lost. Both gamma ray anomalies could be understood as local phase transitions to M_{89} or M_{79} hadron physics. Also the findings of Moshina might be understood in terms of dark atoms.

In both cases, the fluxes of energy and matter arriving from the Sun would be determined at the surface layer and this certainly leads to powerful predictions, which distinguish the TGD view from the standard view. For instance, the power produced in the transformation of the layer to ordinary nuclei should be proportional to the area of the surface and if the density of the start is kept constant and the anatomy of the surface layer does not depend on the size of the star, it should behave like $M^{2/3}$ as function of the stellar mass.

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.

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 $[25, 16.7]$.

1. Energetics for Option II

For Option II the energy liberated per nucleon in the evaporation of single dark layer would be essentially the ordinary binding energy per nucleon, which is few MeVs for $h_{eff}/h = 2^{10}$ suggested by the TGD based model of the "cold fusion" [L2] and in the range $10^{-3} - 10^{-2}$. If the liberated energy is transformed to radiation the ratio R is in the range $10^{-3} - 10^{-2}$. This is in conflict with the experimental findings. This leaves only the totally crazy option under consideration.

Energetics for the Option I

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 introduce p-adic cooling as a process allowing to avoid this [K3, K4, K5] 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.

For Option I the high energy gamma rays, which are not expected to thermalize and they 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 $k \rightarrow k+2$ 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.

It seems that the totally crazy option might work!

2.4 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, L24, L25].

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 [L23].

2. The solid layer at the surface of the Sun [E22] formed by dark M_{107} or, less plausibly, M_{89} monopole flux tubes and identifiable as $n = 1$ orbital in the model of the planetary system as a gravitational hydrogen atom could correspond to a seed of a proto planet, which could be an outcome of an explosion. This explosion might be a phase transition transforming dark $M107$ nuclei or M_{89} nuclei to M_{107} nuclei.

3. Baryon number conservation allows the transformation of say M_{89} nucleons to M_{107}. Unfortunately, it is not possible to say anything about the rate of this process. This explosive process would increase the size of the nucleon by a factor 512 unless M_{89} nucleons are dark having $h_{eff}/h = 512$ in which case they have the same size as ordinary nuclei.

   In the decay of M_{89} nuclei with $h_{eff} = h$ to M_{107} nuclei, a huge binding energy should be liberated. Could this energy burst have thrown a magnetic bubble from the surface of the Sun and led to the generation of the planetary system [L19, L20]? Is this energy quite too large? Is the liberation of the nuclear binding energy in the decay of dark M_{107} nuclei to ordinary nuclei enough?

4. What about dark M_{107} nucleons? In the proposed model there would be about 2^{18+30} dark M_{107} sublayers with $h_{eff}/h = 2^{10}$. This structure would have a thickness of .25 m. A single dark M_{107} layer would correspond to a mass $\sim 6 \times 10^{-9} M_E$. If $\sim 2^{11}$ layers, forming a structure whose thickness is 1.25×10^{-4} m, explodes, a mass of $3M_E$ is thrown out. By the way, a water block with Planck mass has a size of about 10^{-4} m.

5. The evaporation of the predicted BHs (or collapse in the reverse time direction) to form astrophysical objects could correspond to a sequence of expansions of this kind increasing p-adic length scale by factor of 2 in single step (of course, also smaller increments of p are in principle possible). 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. One can of course ask whether the M_{89} could transform M_{107} nuclei by the emission of TeV gamma rays.

6. 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 [K4, K5] that mysterious Centauro, Gemini, etc 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, L23]. 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 [L23, 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.

2.4.1 Two ways to understand planets

TGD suggests two ways to understand planets. 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 monopole flux tubes labelled by M_{89} or about 2^{18+30} dark M_{107} sub-layers with $h_{eff}/h = 2^{10}$ suggested by the TGD based model of "cold fusion" as dark fusion.

1. For the M_{89} option, 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, perhaps quite too 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.

2. Suppose M_{89} layer formed the missing nuclear mass about $1500 M_E$. This predicts the number of M_{89} baryons as $N_{89} = M_{layer}/m_{89} = .005 M_{Sun}/m_{89}$. 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 $M_{layer}/512 = 3M_E$. The mass of the planet formed in the explosion would be smaller than $3M_E$.

3. The dark M_{107} option predicts 2^{38} layers of dark nucleons with $h_{eff}/h = 2^{10}$ and the explosion of 2^{27} dark M_{107} layers forming a structure of thickness 1.25×10^{-4} meters (size of a water blob with Planck mass) throws out a mass $3M_E$. The inner planets could have formed by this mechanism.

   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. It is easy to see that the giant planets couldn't have formed in an explosion of $M_{G,79}$ layer: this would require the layer mass to be larger than the mass of the Sun.

For the second option, planets could correspond to BHs. One can also consider blackhole collapse in reversed time direction. BH option does not look so attractive as the magnetic bubble option.

1. This however requires a generalization of the hypothesis that the BHs correspond to Mersenne primes and their Gaussian counterpars. More general values of k in the p-adic prime $p \simeq 2^k$ characterizing the scale variant of the hadron physics must be allowed. One can estimate the values of k for planets. The lists of the values of k for $\{Mercury, Venus, Earth, Mars\}$ *resp.* $\{Jupiter, Saturn, Uranus, Pluto\}$ is given by $\{(84, 88, 89, 85\}$ *resp.* $\{97, 95, 91, 80\}$. For the Jupiter the value of k is largest and corresponds to $k = 97$.

2. The analog of Hawking evaporation could accompany the expansion and would reduce the BH mass whereas gravitational condensation would tend to increase the mass of BH. In the case of Earth, the BH mass is $4M_E/3$ times larger than the mass of Earth. The loss of mass due to the formation of Moon is only 1.2 per cent and it is not clear how to understand the remaining mass. The model based on explosion looks more plausible.

2.4.2 Supernovae as explosions of magnetic bubbles?

Could the explosions of either M_{89} - or dark M_{107} magnetic bubbles induce supernovae? The following vision suggests itself.

1. The flux tubes as M_{89} or, more probably, of dark M_{107} 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 compensating for the missing contribution due to the missing ordinary nuclear matter inside stars.

2. 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.

3. The pressure pulse created in this way leads to the formation of supernovae and blackhole-like objects? Various giant stars would 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 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} or, more probably, dark M_{107} 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} or dark M_{107} 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.

   In the dark M_{107} case case there would be 2^{18+30} layers of dark nucleons. p-Adic length scale hypothesis suggests that the number of layers lost in an explosion could correspond to power of 2. The disappearance of a structure of 2^{27} layers, having the thickness of 1.25×10^{-4} m, would throw out a mass of about $3M_E$.

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 dark M_{107} layer or 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 or dark M_{107} 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} or dark M_{107} nucleons transform to M_{107} nucleons and the liberated energy throws the loop out of the Sun.

2.4.3 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. Either the local transformation of M_{89} nucleons or, mor probably, dark M_{107} 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.

Solar corona would exist as an analog of accretion disk for the matter arriving from the surface of the Sun created by the above mechanism. The high temperature would be due to the liberated energy. Could the dark M_{107} nuclei at the surface layer of the Sun transform to ordinary ones and get heated to a high temperature. They would cool down and condense back to dark nuclei at the monopole flux tubes of the solar wind. The solar corona as an accretion disk would have 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.

2.4.4 The problems related to the solar convection and solar neutrinos

The solar convection problem [E18], 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, E20]. These findings do not conform with the view that nuclear fusion produces the nuclear matter arriving from the Sun.

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 or dark M_{107} flux tubes split by reconnection to 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 are produced in the $M_{89} \rightarrow M_{107}$ transition. For $M_{107,dark} \rightarrow M_{107}$ transition, one expects that electron neutrinos dominate and here mixing effects would be important. The challenge in both options is to predict the rate of the neutrino production.

The production of neutrinos in the decays of ordinary pions produced as end products of either process 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 is not needed in the model. One can however ask whether the neutrinos could mix strongly in the solar corona and whether neutrinos could be produced in the corona as a side product of dark nuclear fusion.

This picture would 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.

2.4.5 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 [E21] 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 surface layer, magnetic bubble, is active and generates solar wind. This actually conforms with the notion of holography.

2. The solar wind consists of matter emerging from the magnetic bubble forming a thin layer at the surface of the Sun. 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 dark M_{107} nucleons or 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. In fact, in a good approximation Sun is analogous to a quantum harmonic oscillator consisting of mass shells as magnetic bubbles and the evolution of the Sun gradually burns these layers. The analogy with atoms and nuclei is obvious: only the valence shells are active and inner shells are totally silent and interact with the external world! 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 these shells and solar wind is 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 no effects on the shape of the Sun since it is totally passive just like the inner shells of the atom. Astrophysics is extremely simple.

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