Magnetars as a support for the notion of monopole flux tube

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Abstract

Magnetars are final states of supernovae differing from neutron stars in that their surface magnetic fieldsare by a factor 1000 stronger than those of neutron stars. There are two models for how these fields are generated. Dynamo model assigns the magnetic fields to very rapid rotation of charged matter. Second model assumes that they are inherited from the parent stars but this leaves the origin of these magnetic fields in parent stars open - Maxwellian view suggests dynamo mechanism. The recent findings do not favor dynamo model predicting that formation of magnetars should be more energetic process than that of neutron stars. The TGD view about magnetic fields differs from the Maxwellian view. TGD allows no magnetic monopoles but monopole flux tubes obtained from cosmic strings (4-D space-time surfaces with string world sheet as 2-D M^4 projection) by the thickening of M^4 projection. These magnetic fields require no currents so that no dynamo mechanism is needed.

1 Introduction

There is an interesting popular article about magnetars in Quanta Magazine (http://tinyurl.com/uh5r3az). The article tells about the latest findings of Zhou and Vink and colleagues [E2] (http://tinyurl.com/s24dq23) giving hints about the mechanism generating the huge magnetic fields of magnetars.

Neutron stars have surface magnetic field of order 10^8 Tesla. Magnetars have surface magnetic field stronger by a factor 1000 - of order 10^{11} Tesla. The mechanism giving rise to so strong magnetic fields at the surface of neutron star is poorly understood. Dynamo mechanism is the first option. The rapidly rotating currents at the surface of neutron star would generate the magnetic field. Second model assumes that some stars simply have strong magnetic fields and the strength of these magnetic fields can vary even by factor of order 1000. Magnetars and neutron stars would inherit these magnetic fields. The model should also explain why some stars should have so strong magnetic fields - what is the mechanism generating them. In Maxwellian world currents would be needed in any case and some kind of dynamo model suggests itself.

Dynamo model requires very rapid rotation with rotation frequency measured using millisecond as a natural unit. The fast rotation rate predicts that magnetars are produced in more energetic explosions than neutron stars. The empirical findings however support the view that there is no difference between supernovas producing magnetars and neutron stars. Therefore it would seem that dynamp model is not favored.

The TGD view about magnetic fields differs from the Maxwellian view. TGD allows no magnetic monopoles but monopole flux tubes obtained from cosmic strings (4-D space-time surfaces with string world sheet as 2-D M^4 projection) by the thickening of M^4 projection [K1, K2, K3] [L2, L1, L3, L5]. These magnetic fields require no currents so that no dynamo mechanism is needed.

2 TGD view about magnetars

What can one say about magnetars in TGD framework? TGD view about magnetic fields differs from Maxwellian view and this allows to understand the huge magnetic without dynamo mechanism and could give a justification for the inheritance model.

1. TGD predicts that magnetic field decomposes to topological field quanta - flux tubes and sheets - magnetic flux tubes carry quantized magnetic flux. Flux tubes can have as cross section either open disk (or disk with holes) or closed surface not possible in Minkowskian space-time. The cross section can be sphere or sphere with handles.

2. If the cross section is disk a current at its boundaries is needed to create the flux. If the cross section is closed surface, no current is needed and magnetic flux is stable against dissipation and flux tube itself is stable against pinching by flux conservation. These monopole fluxes could explain the fact that there are magnetic fields in cosmological scales not possible in Maxwellian theory since the currents should be random in cosmological scales.

   This also solves the maintenance problem of the Earth's magnetic field. Its monopole part would stable and 2/5 of the entire magnetic field $B_E = .5$ Gauss from TGD based model of quantum biology involving endogenous magnetic field $B_{end} = .2$ Gauss identifiable in terms of monopole flux.

The model for the formation of astrophysical objects in various scales such as galaxies and stars and even planets and also for quantum biology relies crucially on monopole fluxes.

1. The proposal made in [L3] is that stars correspond tangles formed to long monopole flux tube. Reconnection could of course give rise to closed short flux tubes and one would have kind of spaghetti.

   The interior of Sun would contain flux tubes containing dark nuclei as nucleon sequences and one ends up to a modification of the model of nuclear fusion based on the excitation of dark nuclei [L4]. The model solvs a 10 year old anomaly of nuclear physics of solar core [E1, E3]. From the TGD based model of "cold fusion" one obtains the estimate that the flux tube radius is of order electron Compton length, and thus about $h_{eff}/h_0 \simeq m_p/m_e \sim 2000$ times longer than proton Compton length. This has been assumed also in the model of stars discussed in [L3].

2. The final states of stars could correspond to a volume filling spaghettis of flux tube analogous to blackhole. They would be characterized by the radius of the flux tube, which would naturally correspond to a p-adic length scale $L(k) \propto 2^{k/2}$: one could speak of various kinds of blackhole like entities (BHEs). There radius of the flux tube would be scaled up by the value of effective Planck constant $h_{eff} = n \times h_0$ so that one would have $n \propto 2^{k/2}$ in good approximation.

3. The p-adic length scales $L(k)$, with k prime are good candidates for p-adic lengths scales. Most interesting candidates correspond to Mersenne primes and Gaussian Mersennes $M_{G,k} = (1+i)^k - 1$. Ordinary blackhole could correspond to a flux tube with radius of order Compton of proton corresponding to the p-adic length scale $L(107)$.

   For neutron star the first guess would be as the p-adic length scale $L(127)$ of electron from the model of Sun. $L(113)$ assignable to nuclei and corresponding to Gaussian Mersenne is also a good candidate for magnetar's p-adic length scale. $L(109)$ assigned to deuteron would correspond to an object very near to blackhole corresponding to $L(107)$ [L3]. Also the surface and interior of BHE would carry enormous monopole fluxes 32 times stronger than for magnetars.

   The are just guesses but bringing in quantized monopole fluxes together with p-adic length scale hypothesis allows to develop a quantitative picture.

Consider first the flux quantization hypothesis more precisely.

1. The observation that to the vision about monopole magnetic fields and hierarchy of Planck constants now derivable from adelic physics was that the irradiation of vertebrate brain by ELF frequencies induces physiological and behavioral effects which look like quantal. As if cyclotron transitions in endogenous magnetic field $B_{end} = 2B_E/5 \simeq 0.2$ Gauss would have been in question. The energies of photons involved are however ridiculously small and cannot have any effects. The proposal was that the effective value of Planck constant

is quantized: $h_{eff} = nh_0$ and can have very large values in living matter. The energies $E = h_{eff}f$ of photons could thus be over thermal threshold and have effects. The matter with non-standard value of h_{eff} would correspond to dark matter.

2. One can make the picture more quantitative by considering the quantization of flux. The radius r of a flux tube carrying unit magnetic flux is known as magnetic length $r^2 = \Phi_0/e\pi B$, where Φ_0 corresponds to minimal quantized flux $\Phi_0 = BS = B\pi r^2 = n \times \hbar/eB$ for flux tube having disk D^2 as cross section. If B_{end} is ordinary Maxwellian flux one obtains for $B_{end} = 0.2$ Gauss $r = 5.8$ μm which is rather near to $L(169) = 5 \times 10^{-6}$ μm Cell membrane length scale $L(151) = 10$ nm corresponds to the scaling $B_{end} \rightarrow 2^{18}B_{end} \simeq 5$ Tesla and 1 Tesla corresponds to the magnetic length $r = 2.23 \times L(151)$.

   One can argue that one must have quantization of flux as multiples of h_{eff}. The geometric interpretation is that $\hbar_{eff} = n\hbar_0$ corresponds to n-sheeted structure (Galois covering) and the above quantization gives flux for a single sheet. The total flux as sum of these fluxes is indeed proportional to $\hbar_{eff}$.

3. For monopole flux tubes disk D^2 is replaced with sphere S^2 and the area $S = \pi \times r^2$ in magnetic flux is replaced with $S = 4\pi r^2$. This means scaling $r \rightarrow r/2$ for the magnetic length. The p-adic length scale becomes $L(167)$, which corresponds to Gaussian Mersenne is indeed the scale that might have hoped whereas the ordinary flux quantization giving $L(169)$ was a disappointment. This gives a solution to a longstanding puzzle why $L(169)$ instead of $L(167)$ and additional support for monopole flux tubes in living matter. As a matter of fact, there are four Gaussian Mersennes corresponding to $k \in \{151, 157, 163, 167\}$ giving rise to 4 p-adic length scales in the range [10 nm, 2.5 μm] in the biologically most important length scale range. This is a number theoretic miracle.

It is useful to list some numbers for monopole flux by using the scaling $\propto 1/L^2(k) \propto 2^{-k/2}$ to get a quantitative grasp about the situation for magnetars and other final states of stars.

1. For monopole flux $L(151)$ corresponds to $2^{16}B_{end}(k = 167) \simeq 1.28$ Tesla. For ordinary flux it corresponds to 2.56 Tesla. A good mnemonic is that Tesla corresponds to $r = 1.13 \times L(151)$.

2. For neutron star one has $B \sim 10^8$ Tesla. For monopole flux this would correspond for ordinary flux magnetic length $r \simeq 1.13$ pm roughly $2.8L_e$, where $L_e = .4$ pm is electron Compton length. Note that the corresponding p-adic length scales is $L(127) = 2.5$ pm $\simeq 2.2r$ so that also interpretation in terms of $L(125)$ can be considered. For non-monopole flux one would have roughly $r = 2.26$ pm. Neutron star would be formed when all flux tubes become dark flux tubes and perhaps form single connected volume filling structure.

3. For magnetar one has magnetic field about $B = 10^{11}$ Tesla roughly 1000 times stronger than for neutron star. For monopole flux this would give $r = 30$ fm to be compared with the nuclear p-adic length scale $L(113) = 20$ fm. Could the p-adic length scale $L(109) = 2L(107) = 5$ fm correspond to a state rather near to blackhole? $L(109)$ would would have 16 times stronger surface magnetic field $B \simeq .45 \times 10^{12}$ Tesla than magnetar. For the TGD counterpart of ordinary blackhole having $k = 107$ the surface magnetic field $B \simeq 1.8 \times 10^{12}$ Tesla would be 32 times stronger than for magnetar.

All these estimates are order of magnitude estimates and p-adic lengths scale hypothesis only says something about scales.

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