Essay

The Maintenance Problem of the Earth's Magnetic Field

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Abstract

The understanding of the Earth's magnetic field, call it B_E for shortly, is still far from complete. One problem is to understand why it can exist stable at all. The idea is that the convective heat flow from the core of Earth provides the needed energy to compensate for the dissipation. Also the understanding of the orientation reversals of B_E is poor although numerical simulations can reproduce them. The new view about electromagnetic fields provided by TGD suggests a solution to the maintenance problem. The magnetic fields assignable to monopole flux tubes require no currents as sources so that dissipation does not destroy them. B_E would contain the monopole flux part and the purely Maxwellian part.

1 Introduction

For five years ago there was there was an interesting popular article in Science Daily [2] (`https://cutt.ly/2f6UXn4`) about what might be called maintenance problem for Earth's magnetic field, which has very important functions such as serving as a shield against cosmic rays which is very dangerous for life. I published a little note at my homepage about TGD inspired solution of the problem [4].

The understanding of the Earth's magnetic field, call it B_E for shortly, is indeed still far from complete. One problem is to understand why it can exist stable at all. The idea is that the convective heat flow from the core of Earth provides the needed energy to compensate for the dissipation. Also the understanding of the orientation reversals of B_E is poor although numerical simulations can reproduce them.

The popular article explained work by Zhang, Cohen and Haule [1] in which the problem related to the maintenance of convective flow is claimed to be solved. If the conductivity and thus heat conductivity in core is low enough, heat conduction is replaced with convection and this creates the flow of charge too and one obtains convective roll pattern which gives rise to the current taking care that B_E is preserved. The problem is that the conductivity is too high in the metal core. The proposal is that an improved model for the conductivity taking care of electron-electron scattering cures the problem. Knowing how hypish science communications are nowadays, I would not take this claim as final truth.

The problem requires study of Maxwell's equations (for explicit equations see the Wikipedia article (`https://cutt.ly/wf6U0r2`).

1. The first basic equation for B_E is Faraday' equation stating that time derivative of B_E is the rotor of electric field. This is true in TGD too as is also the equation stating that there are no magnetic monopoles. In TGD CP_2 topology however allows monopole fluxes [3], which can exist without any generating currents. Second basic equation is Ohm's law saying that current is proportional to electric field: the proportionality constant is conductivity σ.

   Together these equations give a partial differential equation for B_E containing diffusion term proportional to the Laplacian of B_E with a coefficient inversely proportional to conductivity. Since finite conductivity means dissipation of energy, one can expect that in absence of energy feed, the current and magnetic field gradually disappear. According to a naive estimate this would take few thousands of years. This does not of course happen. Note however that the polarity of B_E can change in time scale varying from .1 My to 50 My.

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2. Energy is needed to maintain B_E and the current generating it. The energy source would be the heat flowing from Earth's core to the surface. If conductivity and thus thermal conductivity (electron current carries also energy and thus heat) in the interior is not too high, the diffusion of heat proportional to conductivity is not high enough to carry out the heat and convection sets on and the stuff begins to boil. The boiling together with Earth's rotation causes rolling flow of the current above core around the earth, and this convective current generates B_E and keeps it alive.

3. The problem has been that the electron conductivity in the metal core is too high in the core to allow convective currents. The authors of paper notice that the existing model for the electronic conductivity in metals involving only electron atom scattering contains an additional contribution from electron-electron scattering and claim that this term cures the situation. It improves the situation but one can still remain skeptic whether this term is really enough.

   What worries me too is that the direction of magnetic axis can differ a lot from that of the rotation axis of Earth. How to understand this difference. Also the apparent randomness of the orientation reversals looks strange.

2   TGD based solution of the maintenance problem

What this has to do with TGD? The basic problem is still to understand the orientation reversals and it is not quite clear that even stability problem has been solved completely.

1. TGD differs from Maxwell's theory in that monopole fluxes are possible and realized as flux tubes for which cross section is closed 2-surface (rather than disk) carrying magnetic charge. Also flux quant are possible carrying monopole flux are possible. These flux quanta would carry also dark matter.

   Could the Earth's magnetic field contains also a dark contribution, call it B_D from monopole fluxes? Could the interaction of visible matter with dark matter be essential for maintaining B_E and for its orientation reversals? Could Magnetic Mother Gaia perform the orientation reversals "intentionally" in order to not lose the magnetic shield against cosmic radiation?

2. The essental point is that monopole fluxes require no currents to generate them. This contribution would give approximately topologically quantized variant of dipole field with flux quanta which could be either flux tubes or sheets and return flux would be along magnetic axis. Suppose that sheets are in question. There would be also corresponding electric field $E = v \times B_D$ at the flux sheets according to the dynamo mechanism. v would be the rotation velocity of the dark particles.

   There would be radial Lorentz force $F = qv \times B_D$ driving charged dark particles radially outwards if the sign of the velocity is current. Could the presence of the Lorentz force causing dark current help to initiate radial convective current of ordinary charged particles bringing hot matter to the surface and cooled matter downwards and in this manner give rise to the convective heat transfer?

3. What about changes of the polarity of the Earth's magnetic flux quanta? Could they be induced by the changes of the direction of the dark magnetic field at dark flux sheets (say). If the flux sheets of monopole field carry a current of rotating charged dark charged particles, the rotation direction changes as the flux quantum changes its orientation. This guarantees a minimal convective flux is radial and towards the surface. Angular momentum would be changed to its negative in full orientation reversal and the increment of the angular momentum would go by angular momentum conservation to the ordinary matter, perhaps mostly to the ordinary electrons and generate electron currents having twice the original dark angular momentum. After this ordinary electrons would start to dissipate the just inherited newly angular momentum again.

4. What could induce the changes of the orientation of B_D? Could the two contributions to the total magnetic field be regarded as two magnetic dipoles having dipole interaction realized as a torque proportional to the cross product of the dipole moments. This would cause orientation changes of the dipoles and thus of the fields. The torque vanishes if the dipoles are parallel and dipoles gradually become parallel by dissipation for B_E. This does not seem to be the mechanism.

Could it be that the dynamics of the dark magnetic flux quanta is purely quantal and induces the dynamics of B_E by angular momentum conservation? As the strength of the B_E becomes too weak to shield Earth from cosmic radiation, the loving Magnetic Mother Gaia takes the lead and turns its magnetic body to to a new orientation, which by angular momentum conservation forces the ordinary electrons to a rotation around new magnetic axis and much brisker B_E is regenerated in new direction. MMM takes would take good care of his prodigal son!

References

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