

Electrostatic Model of the Earth's Magnetic Field: An Alternative Hypothesis Based on a Net Planetary Charge

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ABSTRACT

This article presents an alternative hypothesis regarding the origin and variability of Earth's magnetic field. Unlike the conventional model, which attributes the field to electric currents in the liquid outer core, the proposed model considers the existence of a net electrostatic charge distributed over the Earth's crust, whose rotation would produce a dipolar magnetic field. This framework also provides a possible explanation for magnetic field reversals and the misalignment between the magnetic and geographic poles. The feasibility of such a planetary charge is supported by the properties of the solar corona, which could create favorable conditions for the Earth to acquire and maintain a current net negative charge. Order-of-magnitude calculations show that the proposed mechanism is compatible with current physical observations and constraints. In line with this model, recent measurements confirm the existence of a powerful planetary electrostatic field.

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Introduction

Geological records indicate the presence of Earth's magnetic field for at least 3.45 billion years [1]. The conventional explanation attributes it to electric currents generated in the conductive, liquid outer core [2,3], yet this hypothesis leaves unanswered questions regarding the origin and sustained maintenance of these currents. It also struggles to explain phenomena such as the periodic reversals of the magnetic field, which imply its extinction and subsequent regeneration in the opposite direction.

This work proposes a different hypothesis: the existence of a net electrostatic charge on the Earth's crust (including continental masses, oceans, and atmosphere), whose rotation would generate the observed magnetic field. This perspective allows for a coherent interpretation of anomalous features of the field, including reversals and its deviation from the Earth's geographic axis.

Proposed Model: A Charged and Rotating Sphere

Under normal conditions, significant electrostatic potential differences exist near the Earth's surface. Records indicate that even on calm days, differences of over one million volts occur between the surface and the upper layers of the atmosphere. This phenomenon is documented on a planetary scale across the entire surface. However, these high electrostatic potentials do not produce visible manifestations except during electrical

storms, in which the potential differences rise to levels capable of ionizing the air.

To propose the idea of a net electrostatic charge on Earth, one must assume that similar potentials also exist at the scale of the solar system, where the interplanetary vacuum would make their detection and quantification extremely difficult. As will be shown, the solar corona's plasma plays a dominant role in this model.

The simplified model presented here considers Earth as a sphere with a net electrostatic charge that, by rotating on its axis, would give rise to a magnetic field with a dipole approximately aligned with the rotation axis. A non-uniform charge distribution (associated with the varying distribution of surface masses and the presence of air and water currents) would result in a certain degree of misalignment between the geographic and geomagnetic axes, consistent with observations.

Furthermore, when Earth is observed from a point above the geographic North Pole, it appears to rotate counterclockwise. Thus, following the conventional definition of magnetic poles, if the planet holds a net charge, it would need to be negative, since this point corresponds to what is conventionally called the magnetic South Pole.

Model Justification

It is important to emphasize that the model proposed does not stem from direct measurements but from a conceptual approach intended to explain the existence and behavior of certain phenomena at the

solar system scale and others at the planetary scale.

- At the solar system scale, the model includes a phenomenon associated with the temperature of the solar corona. Due to their much greater velocity, only electrons (and not positive ions) can escape the Sun's gravitational pull, inevitably leading to charge segregation.
- At the terrestrial scale, the model addresses the nature of geomagnetic polarity reversals. These reversals do not occur as in a solenoid flipping in space but through a sequence of extinction and reemergence with inverted polarity, without any actual "rotation" of the magnetic poles.

The Solar Corona

A key condition for conceptually supporting this model lies in the possibility that Earth currently holds a significant net negative charge. In this regard, studies [4] indicate that the solar corona, composed mainly of protons, helium nuclei, and electrons, has an average temperature of about 2,000,000 K. Under these conditions, the differential behavior of these ions can be calculated.

Using approximate figures for clarity, at the indicated temperature, the average velocity of electrons is nearly 8,000 km/s, while that of protons is slightly below 200 km/s. Since the Sun's escape velocity is around 600 km/s, only the electrons would be able to escape the Sun's gravitational pull en masse. However, this initial scenario (assuming a star with no net electrostatic charge) would quickly result in the Sun becoming positively charged and the surrounding space acquiring a negative charge.

This process would lead to the establishment of an "electrostatic equilibrium" involving continuous ion recombination at lower temperatures than that of the solar plasma and a renewed emission of electrons from the corona to maintain a net positive charge in the Sun.

This simplified model enables the possibility that Earth may indeed have a net electrostatic charge and, consequently, generate its magnetic field as a result of planetary rotation.

Geomagnetic Field Reversals

One of the most remarkable anomalies of Earth's magnetic field is its periodic reversal [5].

Within the framework of this model, reversals may be explained as a consequence of shifts in the position of the electrostatic equilibrium zone—between the positive charges near the Sun and the negative ones in the periphery—with respect to Earth. If, due to variations in the solar corona's temperature, Earth were to move from a region dominated by negative charges to one dominated by positive charges, the magnetic field would momentarily disappear and then reconfigure itself in the opposite direction, following the same patterns documented throughout Earth's geological history.

In short, the reversal of the magnetic field would not involve changes in the rotation of currents associated with Earth's core, but rather would result from shifts in the distribution of charges within the solar system, possibly linked to variations in solar activity and, consequently, its corona.

Magnitudes of Electrostatic Charges

This model is only viable if the electrostatic charges involved are of such magnitude that they can persist over time without, for example, affecting atmospheric equilibrium or significantly interfering with gravitational interactions within the solar system.

To account for the magnetic dipole moment of Earth's field (roughly $10^{22} \text{ A}\cdot\text{m}^2$), taking into account Earth's rotational speed and assuming the electrostatic charge is uniformly distributed across the crust, the required charge would be on the order of 5×10^{13} coulombs. While this value may initially seem very large, it would be distributed across atmospheric, oceanic, and land masses. Assuming, based on average density, that only one-thousandth of this charge resides in the atmosphere (approximately 10^{10} coulombs), this would equate to about 10^{19} electrons per km^3 , considering each electron carries 1.6×10^{-19} coulombs. This amount is on the same order of magnitude as the charge needed in the upper atmosphere to generate the previously mentioned potential difference of more than one million volts relative to the planet's surface, under calm atmospheric conditions.

This initial result is considered fully compatible with the model's requirements, as it involves net charges of the same order as those currently present in the planetary system.

A second calculation, related to the required electrostatic repulsion between Earth and the Moon, indicates that this repulsion (assuming the Moon's charge is between 100 and 1000 times smaller than Earth's, based on surface area and the absence of an atmosphere) is less than one ten-thousandth of the Earth-Moon gravitational force.

This result, too, would be compatible with the model's requirements, as the resulting perturbation would be negligible in the already complex dynamics of the Sun-Earth-Moon system.

Finally, it remains to be assessed whether the Sun could have generated charges of the magnitude required by the electrostatic model of geomagnetism.

In this case, considering the escape velocity of electrons, for them to be retained within the solar system, the Sun would need to have developed a net charge of approximately 10^{17} coulombs.

This value—about 10,000 times greater than the charge Earth would need to generate its geomagnetic field—also appears compatible with the model's requirements, though it necessitates a far more complex modeling than the conceptual sketch presented here.

Other Planets

To reconcile this proposal with the magnetic fields of the outer planets, it is necessary to recognize that the proposed model applies to the scale of the Sun and its vicinity.

Accordingly, the magnetic fields of the more distant planets would need to be explained by locally generated charges (each planet generating its own net charge) or by interaction with galactic-scale charges.

- In the case of Jupiter, the ongoing generation of extremely powerful electrical storms in its atmosphere (and the well-documented electromagnetic interaction between Jupiter and its moon Io) could suggest a behavior similar to that of the Sun, albeit on a much smaller scale. In this way, a rotating planetary sphere with a net positive charge would account for a magnetic field inverted with respect to Earth's current field, but with the same direction of rotation.
- Similar considerations would apply to Saturn, whose smaller diameter and lower atmospheric turbulence result in a weaker magnetic field but with the same orientation as Jupiter's.

- Venus and Mercury, in turn, would have their weak magnetic fields justified by their slow rotation (both planets) and, in the case of Mercury, its smaller size compared to Earth.
- As for Mars, one might assume that it lies beyond the region of net charges to which Earth belongs and, lacking atmospheric instabilities and the intense electrical discharges seen in Jupiter and Saturn, would have no reason to maintain a significant surface net charge, consistent with its very weak magnetic field.

The Sun presents a very different scenario, as positive charges would accumulate in the corona, from which electrons would be preferentially expelled. The Sun's surface, with its much lower temperature (around 5,500 K), would not promote charge separation, so its net charge could differ from that of the corona (always positive but variable depending on plasma temperature). This could account for the periodic reversal of the Sun's magnetic field, which follows the patterns of maximum and minimum solar activity.

Additional Data

As mentioned earlier, it is unlikely that Earth's net charge is concentrated solely in atmospheric layers. In fact, given their density and thickness, it is expected that most of the net charge resides in the crust, both in continental landmasses and in large bodies of water.

This model may also offer an initial explanation for the significant electrical discharges documented during earthquakes and volcanic eruptions. If large charge accumulations exist in the crust, subsurface potential differences could be on the same order of magnitude—or even greater—than those measured in atmospheric layers. Thus, during rapid displacements of blocks or magmatic flows (non-conductive materials), the electrostatic field imbalances could trigger the observed discharges during such geological events.

Experimental Data

According to recent news, the existence of a global electrostatic field on Earth was confirmed through a NASA mission using a suborbital rocket. In the available reports it is mentioned that this global ambipolar electric field, observed in August 2024, plays a crucial role in shaping the ionosphere and enabling atmospheric escape, particularly near the poles (NASA, 2024). Such findings reinforce the plausibility of models that consider large-scale charge separation and rotation as potential contributors to the geomagnetic field.

Calculation of the Required Net Charge

Assuming that the Earth's crust is the main cause of the dipole moment and knowing that the magnetic dipole moment of a rotating charged hollow sphere is given by:

$$m = \frac{1}{2} q \cdot R^2 \cdot \omega$$

where:

m : Dipole moment (in $A \cdot m^2$). Ampere per square meter

q : Net electrostatic charge (in Coulombs)

R : Radius of the sphere (in meters)

ω : Angular velocity (in radians/second)

Taking into account that Earth's dipole moment is about $8 \times 10^{22} A \cdot m^2$, its angular velocity is 7.27×10^{-5} , and its radius is 6.4×10^6

m, solving for "q" gives:

$$q = 5.4 \cdot 10^{13} \text{ coulomb}$$

Conclusions

The proposed electrostatic model provides an alternative explanation for the origin and anomalies of Earth's magnetic field. This model is not only compatible with the existence of a net surface charge on Earth but also accounts for geomagnetic reversals as consequences of changes in solar activity and charge distribution within the solar system.

References

1. McElhinney TNW, Senanayake WE (1980) Paleomagnetic evidence for the existence of the geomagnetic field 3.5 Ga ago. *Journal of Geophysical Research* 85: 3523.
2. Kageyama A, Sato T (1995) Computer simulation of a magnetohydrodynamic dynamo. II. *Physics of Plasmas* 2: 1421-1431.
3. Glatzmaier GA, Roberts PH (1995) A three-dimensional convective dynamo solution with rotating and finitely conducting inner core and mantle. *Physics of the Earth and Planetary Interiors* 91: 63-75.
4. Aschwanden MJ (2004) *Physics of the Solar Corona. An Introduction*. Praxis Publishing.
5. Agueda J (1977) *Geología*. Madrid: Editorial Rueda.
6. NASA (2024) NASA discovers long-sought global electric field on Earth. Science Mission Directorate – Heliophysics Division. Retrieved from <https://science.nasa.gov/science-research/heliophysics/nasa-discovers-long-sought-global-electric-field-on-earth>.

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