The Origin of Polarity Asymmetries in the History of the Geomagnetic Field

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Paleomagnetic studies of the behavior of Earth's magnetic field suggest that the field has exhibited persistent polarity asymmetries throughout recent geologic time, with relative amplitudes of the lowest several multipole moments differing between the "normal" polarity state and the "reversed" polarity state. This paper examines the behavior of magnetohydrodynamic stationary modes in the presence of an imposed weak magnetic field originating separately from the dynamo. A rare class of stationary states is found that exhibit high sensitivity to the presence of weak imposed fields. The amplitude of the difference between the total fields of opposite polarity is much larger than the amplitude of the imposed nondynamo fields. It is proposed that Earth's magnetic field operates in such a mode, highly sensitive to the presence of an ambient field. An argument, based on the possible mechanisms of dyanamical equilibration of dynamo magnetic fields, is given to explain why the terrestrial dynamo should choose to operate in one of these rare states. Implications are discussed for the general mechanism of dynamo magnetic field equilibration in planets.

Magnetic Flares in the Protoplanetary Nebula and the Origin of Meteorite Chondrules

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Meteoritic chondrules apparently resulted from very rapid, transient, and short-lived heating events in the otherwise much cooler protoplanetary nebula where the meteorites formed. This paper proposes and analyzes a model for the chondrule forming heating events based on magnetohydrodynamic flares in the corona of the protoplanetary nebula which precipitate energy in the form of energetic plasma along magnetic field lines down toward the face of the nebula. It is found that flare energy release rates sufficient to melt prechondrular matter, leading to the formation of chondrules, can occur in the tenuous corona of a protostellar disk. Energy release rates sufficient to achieve melting require that the ambient magnetic field strength be in the range that has been inferred separately from independent meteorite remanent magnetization studies.