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Dynamics of the Earth and planetary dynamos revealed by numerical dynamo simulations

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It is generally believed that dynamo action working in its fluid core is the origin of the planetary magnetic field. Fluid flow is driven mainly by thermal and compositional buoyancy, sources of which are ascribed to secular cooling of the core, heat source due to radioactivity, latent heat and light element release duo to inner core nucleation. Essentially these buoyancy sources are related to the core-mantle boundary (CMB) and inner-core boundary (ICB). Thus, physical and dynamical states of the outer core and its dynamo are strongly related with these boundaries.

By taking effects of the boundaries into account in dynamo simulations, many dynamo modelers have tried to explain characteristics of the magnetic field of each planet. As to the geodynamo, it is found that changes in polarity reversal frequency are governed by CMB heat flux distributions. For the ancient Martian dynamo, the hemispherically biased CMB heat flux (degree-1 pattern) imposed possibly due to mantle convection or giant impact can yield hemispherical dynamo consistent with north-south dichotomy of crustal magnetic field of Mars. The Mercurian extremely weak magnetic field may be explained by stable stratification of the upper part of the core due to sub-adiabatic thermal structure of the Mercury's core, or by iron-snow zone located midway of the core, which is the result of sulfur concentration and pressure condition of Mercury. In this talk, we review such progress and recent topics of dynamo simulation and discuss future prospects of numerical dynamo modeling.

Keywords: dynamo, core, convection, CMB, stratification