Magnetohydrodynamic numerical simulation of geodynamo with length-of-day variation

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Geomagnetic field variations and ice ages may be linked through the length-of-day (LOD) variation of the Earth. Hamano (1992) has pointed out the relations between geomagnetic field variation and the LOD variation caused by redistribution of water mass on the Earth in ice and non-ice ages associated with the Milankovitch cycle. The estimated perturbation to the outer core convection by the LOD variation, O(10E-3) m/s, is almost equal or ten times larger than the outer core convection velocity; very large influence to the outer core. Perhaps it affects magnetohydrodynamic dynamo process in the outer core. In this paper we show the results of the magnetohydrodynamic geodynamo numerical simulation with LOD variations. The Ekman number is 1.9E-5, Rayleigh number 1.5E8, and both Prandtl and magnetic Prandtl numbers are unity. When there is no LOD variation, amplified magnetic energy in the core is several times larger than the convection kinetic energy, and the strong magnetic field and dominant dipole moment is maintained. At a saturated state, a LOD variation is introduced, where the period of LOD variation is almost the same as the magnetic dipole diffusion time. It is about twenty thousand years in the Earth, and nearly corresponds to one of the Milankovitch cycle. The amplitude of two percent is assigned to the LOD variation.

The numerical simulation results show geomagnetic field variation arises due to the LOD variation. The convection kinetic energy also varies. The amplitude of geomagnetic field variation is several tens of percent, and the period is the same as the LOD variation. However, the phase is not same; the gap is about 45 degree. Compared with the time difference of the rotational speed, clearer relation emerges. The peak (valley) of the magnetic energy corresponds to the valley (peak) of the time difference of the rotational speed; the phase gap is 180 degree. In addition, there is the other important variation value; the heat flux at the core-mantle boundary. The amplitude of the heat flux change is about 10 percent. The key to understand the geomagnetic field variations by LOD variation is Joule heating. We also found that the amplitude ratio of the magnetic field variation to the LOD variation depends on the Ekman number. In this paper detail mechanism of the geomagnetic field variations will be shown.