Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SEM21-14 Room:301B Time:May 25 14:45-15:00

Effects of latitudinally heterogeneous buoyancy flux conditions at the inner boundary on MHD dynamo

SASAKI, Youhei[1*], TAKEHIRO, Shin-ichi[2], NISHIZAWA, Seiya[4], NAKAJIMA, Kensuke[3], HAYASHI, Yoshi-Yuki[4]

[1]Dept. Math., Kyoto Univ., [2]RIMS., Kyoto Univ., [3]Dept. Earth Planet. Sci., Kyushu Univ., [4]Center for Planetary Science

Outer core flows, contributing to generation and maintenance of the intrinsic magnetic field of the earth, is considered to be driven by buoyancy caused by the light elements released at the inner core boundary (ICB) through selective condensation of iron and nickel along with the inner core growth. On the other hand, existence of inner core flows has come to be studied as a candidate of the origin of the anisotropy of seismic velocity in the inner core (Karato, 1999; Yoshida et al., 1996; Takehiro, 2010). The typical flow pattern expected in the inner core is axisymmetric and flows are directed from the equatorial region to the polar regions or vice versa. Since such a flow accompanies mass flux through the ICB, it affects the condensation process of iron and nickel, and as a result, latitudinal heterogeneity of the buoyancy (light elements) flux is expected to occur at the ICB.

In the present study, we investigate effects of latitudinally heterogeneous buoyancy flux at the ICB on dynamo process in the outer core through numerical experiments of a 3-dimensional rotating spherical MHD Boussinesq dynamo model. The buoyancy flux vanishes at the core-mantle boundary (CMB), while the distribution of buoyancy flux at the ICB consists of a homogeneous component and a spherical harmonic function with degree 2 and order 0. Three types of the buoyancy flux at the ICB is considered; 1) homogeneous distribution, 2) strong flux around the equatorial region and weak flux around the polar regions, 3) strong flux around the polar regions and weak flux around the equatorial region. The ratio of the inner and outer radii, the Prandtl number and the Ekman number are fixed to 0.35, 1, 10^{-3}, respectively. The magnetic Prandtl number is varied from 1 to 10, and the modified Rayleigh number is from 100 to 500.

Firstly, numerical time integrations of purely compositional convection are performed starting with a point wise disturbance of light element concentration. After statistical equilibrium states are established, MHD dynamo calculations are performed by adding dipole magnetic field. Flow fields of fully developed non-magnetic compositional convection with different ICB buoyancy flux patterns are similar except for the distributions of mean zonal flow. However, a prominent difference in development and maintenance of magnetic field becomes apparent in the MHD dynamo calculations. Solutions with simultaneously developed and sustained magnetic field (dynamo solutions) are obtained in the cases of homogeneous buoyancy flux and strong equatorial flux. On the contrary, in the case of strong polar buoyancy flux, all solutions are failed to sustain the magnetic fields in the surveyed ranges of the parameters. This difference in development of magnetic fields is considered to be affected by the different pattern of mean zonal flow. In particular, in the case of strong polar buoyancy flux, direction of mean zonal flow around the inner core is reverse through the thermal wind balance and strong shear layer is produced there. This shear may stretch the convection columns and prevent localization of the vortex columns and magnetic field.

The consequence that dynamo solution cannot be established when strong flux is given around the polar region might suggest the flow direction of the earth's inner core, because such a buoyancy flux pattern may be unfavorable for development and maintenance of the strong geomagnetic field. It may not be expected that the inner core flows is directed from the polar regions to the equatorial region. However, since the values of the parameters dealt with the present study are quite different from those of the real central core of the earth, further investigation in more broad ranges of the parameter space is needed.

References:
Karato, S., Nature, 402 (1999), 871–873.
Yoshida, S., Sumita, I., Kumazawa, M., J. Geophys. Res., 101 (1996), 28085–28103.
Takehiro, S., Phys. Earth Planet. Inter., 184 (2011), 134–142.

Keywords: Inner core anisotropy, Inner core flows, Heterogeneous bouyancy flux, Compositional convection, MHD dynamo