R004-04
Zoom meeting A ：11/4 AM1 (9:00-10:30)
09:45-10:00

Study of the equatorial symmetry of flow and magnetic field in reversal and non-reversal dynamo models

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Paleomagnetic observations revealed that the geomagnetic field has reversed its polarity every hundreds of thousands to millions of years and each reversal typically takes 2000-12000 years to occur. Some numerical dynamo simulations represented dipole reversals and gain insight into physical processes that give rise to polarity reversals.These dynamo simulations revealed a strong inverse correlation between the stability and the equatorial symmetry of the simulated field (Coe and Glatzmaier, 2006). This result is consistent with the paleomagnetically inferred degree of the symmetry of the Earth's magnetic field during the past 150 Ma, which reversed polarity more frequently when the geomagnetic field was more symmetrical with respect to the equator (McFadden et al.,1991). From insight of the induction equation, anti-symmetric flow has an important role to generate the symmetric magnetic field from the dipolar magnetic field. Olson et al., (2004) proposed a process of magnetic polarity reversals in a dynamo model. In their model, the reversed magnetic field flux is produced locally in the convective plumes and transported from south to north by the meridional circulation. This result suggests that asymmetric flow with respect to the equator play a role in reversals. However, it is an open question how to generate anti-symmetric flow under the condition of the strong rotation because symmetric flows with respect to the equator is dominant under the strong rotation condition. In the present research, we investigate how asymmetric flow is growing and maintained in the dynamo in which reversals occur.
In the present study, we perform two dynamo simulations with reversals in order to compare the equatorial symmetry between the cases with and without reversals, using a geodynamo code Calypso [Matsui et al., 2014]. In Case A, we set the fixed temperature condition at the inner and outer boundaries, and set the Ekman, Prandtl, magnetic Prandtl and Rayleigh numbers to $E = 10^{-3}$, $Pr = 1$, $Pm = 5$ and $Ra = 400$, respectively. In Case B, we set the fixed heat flux condition at the inner and outer boundaries, and set the dimensionless numbers to $E = 6*10^{-4}$, $Pr = 1$, $Pm = 5$ and $Ra = 1540$, respectively. In Case B, Ra is derived from the time average of temperature difference between boundaries. For each case, we investigate the time series of dipole tilt angle, kinetic and magnetic energy for symmetrical and asymmetrical components. In Case A, the time average for the ratio of magnetic to kinetic energies is 0.05, and correlation between polarity reversals and amplitude of the energies are not found. Symmetric part and asymmetric part of the kinetic energy are anti-correlated, so both may have different energy source. For Case B, in which the time average for the ratio of magnetic to kinetic energies is 0.6, a clear relation between the tilt angle and the energies is observed. During the reveal and excursion, kinetic energy grows, and the asymmetric magnetic energy ceases more than symmetric part. Consequently, the symmetric and anti-symmetric energies become comparable. On the contrary, the kinetic energy decreases and the asymmetric magnetic field recovers when the dipole magnetic field sustains stably. We discuss a detailed analysis for the flow and magnetic field structure in these reversal cases and investigate more cases without reversal and stable dipole field.