R004-01
D 会場 ： 11/25　PM1（13:45-15:45）
13:45〜14:00:00

熱・組成拡散方程式モデルに基づく地球外核最上部の安定成層形成について：長時間磁場生成との共存条件

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A condition for long-term geodynamo operation with a stable stratified layer at the top of outer core

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Seismic waveform analyses and fluid motion studies linked to geomagnetic fluctuations suggest that a stably stratified layer could be emerged at the top of the outer core. To test this possibility, Nakagawa et al. (2023) evaluated the kinetic energy production rate in a one-dimensional radial convective structure computation; a stable stratification was defined where this rate is negative (i.e., convection is suppressed). Their results indicate that sustaining both a long-lived geodynamo and a stable layer at the top of outer core requires a present-day core-mantle boundary (CMB) heat flow around 13 to 14 TW. In contrast, Nakagawa (2018) developed a formation model for the stable layer based on thermal and chemical diffusion, but did not assess whether such a layer can coexist with a long-term magnetic field. Here, I revisit the diffusion-based framework in Nakagawa (2018) to evaluate whether a stable layer at the outermost outer core can operate the geodynamo over ˜4 billion years.

The analysis indicates that the dominant mechanism for stable stratification is compositional origin, driven by the injection of light elements from the silicate mantle into the outer core. A thermal stratification, by contrast, emerges only when the present-day CMB heat flow is lower than the isentropic heat flow. With respect to sustainability of geodynamo operation, the results suggest that long-term magnetic field generation - persisting over ˜4 billion years - requires a present-day CMB heat flow of ˜12 TW. Comparing these findings with conditions inferred from radial one-dimensional convective structure computation shows that the overlap between stable stratification and sustained magnetic field generation occurs at a present-day CMB heat flow of 12 to 14 TW. In this regime, a stable layer is primarily caused by the compositional effect, arising from the injection of light element from the silicate mantle associated with the core-mantle chemical coupling. This estimated range of CMB heat flow is consistent with constraints from geophysical observations, numerical modeling, and high-pressure material properties. Taken together, these results support the view that a stably stratified layer at the top of the outer core can coexist with long-term geodynamo operation.