Onset of top-down and bottom-up compositional convection in rotating spherical shells

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The terrestrial bodies that maintain their intrinsic magnetic fields have dynamos in the fluid cores, in which convection is developed by a certain kind of compositional bouyancy sources. In the Earth' s core, it is given by light element ejection into the outer core caused by inner core growth. In other words, convection occurs as a "bottom-up" type convection. On the other hand, iron ejection due to solidification of iron could occur at the core-mantle boundary under a certain condition, and the solidified iron falls downward like snow drop, that is so-called "iron snow". The iron can remelt, and then the fluid motion is driven as a "top-down" type convection. The solidification depth strongly depends on temperature-pressure conditions and bulk sulfur content within the core. In this study, the basic features of the flow driven by these two types of convection are investigated.

For this purpose, onset of top-down and bottom-up compositional convections in rotating spherical shells are studied as a linear stability problem. We consider the Boussinesq fluid contained in rotating spherical shells, of which radius ratio is 0.2. The linearized governing equations, that is, conservation equations of the momentum and mass, and the transport equation of composition, are solved as an eigenvalue problem. The adopted values of the Ekman number, *Ek* range from 2× *10-4* to *10-3* . Boundary conditions are stress-free and impermeable for the velocity field, and fixed flux for composition. In a result, it is found that the critical Rayleigh numbers *Rac* shows a Ekman-number-dependence *Rac∝Ek-1.56* for the top-down convection and *Rac∝Ek-1.69* for the bottom-up convection. In this presentation, these results will be discussed in detail.

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