A numerical study on thermo-compositionally driven dynamo models

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Currently convection in the Earth's fluid outer core is powered by thermal and compositional buoyancy release arising at the inner core boundary (ICB) and core mantle boundary (CMB). Compositional buoyancy is fueled via inner core growth, while thermal one is by secular cooling of the core or uniform internal heat source such as radioactive decay. Conventionally, these two agents are treated in terms of co-density approach, in which temperature and light element concentration are unified into one variable, assuming that the thermal and compositional diffusivity coefficients are equal due to effects of turbulence in the core. However, validity of the assumption and effects of different diffusivities on core flow and dynamo action have not been well studied. Here, we investigate the effects by treating temperature and composition separately in numerical dynamo modeling. We adopt the following dimensionless parameters: Ekman number E = 3x10^{-4} and 10^{-4}, magnetic Prandtl number Pm = 3, thermal Prandtl number Pr^T = 0.1, compositional Prandtl number Pr^C = 1, and thermal and compositional Rayleigh numbers Ra^T and Ra^C. Sum of the two Rayleigh numbers is fixed to keep the same ICB buoyancy flux, while their respective contributions are varied. Fixed and zero flux conditions are used for temperature and composition at the CMB, whereas temperature and composition are fixed at the ICB. With the model setup mentioned above, we have obtained weak field dynamos with non-dipolar or hemispherical structure, when thermal buoyancy exceeds compositional one. On the other hand, strong field dipolar dynamos appear, when compositional buoyancy dominates. Some test runs are performed to examine robustness of the results by changing the initial condition and ICB boundary condition. Robustness and implications of the results for the geodynamo will be discussed.