Construction of a lunar dynamo evolution model consistent with thermal history calculations

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The lunar core is made of an iron alloy like the Earth. As the Moon cooled over geologic time, the solid inner core started to grow at a certain time. According to seismic observations, the current inner core radius relative to that of the outer core seems to be 0.7 to 0.75 (Weber et al., 2011). Now the Moon has no intrinsic magnetic field unlike the Earth. The reason is probably because the reduced thickness of the outer core due to inner core growth is not enough to sustain the lunar dynamo. Paleomagnetic measurements reveal that at least between 4.25 and 3.56 Ga, a magnetic field of the same magnitude as the surface magnetic field of the present Earth existed on the Moon (Weiss et al., 2014).

In order to study the evolution history of the ancient lunar dynamo, we use numerical dynamo modeling varying inner core size. In the modeling procedure, we must adopt some dimensionless parameters appropriately so as to trace the core evolution curve in the parameter space. To do this, assuming chemical composition of the lunar core as Fe-FeS system, we calculate a thermal evolution of the lunar core using a two-layer model by Scheinberg et al. (2015). With this model, we perform a parameter survey regarding the CMB (Core-Mantle Boundary) heat flux and the initial sulfur concentration in the core to find a range of the parameters yielding a reasonable size of the inner core compared with the seismic observation (Fig. 1).

Then, we calculate the Ekman number and Rayleigh number, which are used as input parameters of numerical dynamo simulations, as functions of the inner core radius, or the ratio of the inner core radius to that of the outer core. Here we focus on a period after inner core solidification, when compositional convection caused by release of light elements would mostly drive the dynamo. Therefore, we define the Rayleigh number using the mass flux at the ICB (Inner-Core Boundary). The time-dependent ICB mass flux at a certain age is given from the thermal history calculations as well as the inner core size. With a guide of the thermal history models, we finally draw a core evolution curve with respect to the Ekman number and the Rayleigh number. The present results provide us with a reference curve to construct a lunar dynamo evolution model. Along the curve, we will perform dynamo simulations to examine the lunar dynamo evolution, and report our preliminary results in the presentation.

Keywords: Lunar dynamo, Lunar magnetic field, Thermal evolution, Chemical(Compositional) convection, Inner core growth



