Sustainable dipolar morphology of a lunar dynamo driven by compositional convection

Fumi Hyodo[1]; Futoshi Takahashi[2]; Satoshi Kaneshima[2]; Hisayoshi Shimizu[3]; Hideo Tsunakawa[4]
[1] Earth and Planetary Sciences, Kyushu Univ.; [2] Kyushu Univ.; [3] ERI, University of Tokyo; [4] Dept. Earth Planet. Sci., Tokyo TECH

The paleomagnetic data of the Moon indicates that the lunar dynamo existed for a period of at least 4.2 to 3.56 Ga [Weiss and Tikoo, 2014]. As Laneuville et al. (2014) suggest that the inner core growth of the Moon is likely to last until now, we assume the lunar dynamo is caused by the chemical convection due to the ejection of light elements at the inner core boundary (ICB) upon core crystallization. In dynamo simulations, the Rayleigh number Ra and the Ekman number E are important parameters. We calculate them as a function of time with a help of thermal history model of the Moon [Sheinberg et al., 2015]. Besides, inner core size is varied discretely with respect to the radius ratio $x=r_i/r_o$, where r_i and r_o are the radii of the inner core and the outer core, respectively. Here, guided by our thermal history calculations, we focus on the range of x from 0.3 to 0.5, which roughly corresponds to the duration when the lunar dynamo is supposed to be in operation (i.e. 4.2 to 3.56 Ga). In this presentation, we report our dynamo simulation results in terms of two viewpoints about Ra and E. Firstly, parameters are given according to thermal evolution calculations, namely, (Ra, E) = ($1.1*10^4$, $2.0*10^{-4}$) at x=0.3, ($7.3*10^3$,$2.8*10^{-4}$) at x=0.4, and ($2.9*10^3$,$4.0*10^{-4}$) at x=0.5. Along this line, dipolar-dominant dynamos are obtained. Magnetic field strength at the lunar surface and dipolarity increase with increasing x. Secondly, only Ra is varied with E kept unchanged at $2.0*10^{-4}$ at x=0.3, $2.8*10^{-4}$ at x=0.4, and $4.0*10^{-4}$ at x=0.5. In the cases of Ra=$8.8*10^3$ at x=0.3, Ra=$6.1*10^3$ at x=0.4, and Ra=$2.4*10^3$ at x=0.5, the dipole component remains dominant at x=0.3 and 0.4, and then gives way to the non-dipole components at x=0.5. Magnetic field strength at the lunar surface and dipolarity have a maximum at x=0.4. The surface field at x=0.3 and 0.4 are about ten times stronger than that at x=0.5. These results show that the form of a lunar dynamo evolution changes greatly with the size of Ra given along our thermal history calculations.