Experimentally inferred thermal conductivity of planetary cores

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Paleomagnetism and astrophysical studies revealed the present or past existence of a magnetic field in telluric planets and satellites in our solar system. The dynamo process in the liquid core is the most plausible mechanism for generating a long-lived magnetic field in the rocky planets and satellites. The presence or absence of a dynamo in a terrestrial body depends on the thermal history and energy sources in these bodies, especially the convective state of the liquid core and the existence of a growing solid inner core. The rocky planets are thought to have iron-rich cores, although the exact chemical composition is still under debate even for the Earth.

In order to understand the mechanism of the Earth’s core dynamo action, many efforts have been made to determine the electrical resistivity (the inverse of electrical conductivity) and thermal conductivity of the Earth’s core materials (Gomi and Hirose, 2015). However, the experimental studies have mainly worked on the electrical resistivity measurements of iron and iron-silicon alloys. There is no report of sulfur and hydrogen alloying effects on the electrical and thermal transport properties of iron despite the importance of these elements as major light element candidate(s) in the core.

Recently, we constrained the effects of sulfur and hydrogen incorporation on the conductivity of iron by means of the high-pressure experiments (Suehiro et al., 2017; Ohta et al., in prep.). Based on the results, we estimated the thermal conductivity profiles of planetary cores. The obtained conductivity profile of Martian core, for instance, increases from 46 W/m/K at the core-mantle boundary to 62 W/m/K at its center, and the profile differs from the conventionally assumed value. Our new estimates of planetary core conductivity may alter the current knowledge of the thermal structure and evolution of telluric planets and satellites.

References

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キーワード：惑星コア、電気伝導度、熱伝導率、鉄合金、高圧実験

Keywords: planetary core, electrical conductivity, thermal conductivity, iron alloy, high pressure experiment

