Impurity effect on the iron’s transport properties at Earth’s core conditions: A key constraint for the evolution of the Earth’s core

*Youjun Zhang[1], Mingqiang Hou[2], Nilesh Salke[2], Jung-Fu Lin[3]

1. Sichuan University, 2. HPSTAR, 3. University of Texas at Austin

The Earth’s core is mainly composed of Fe-Ni alloyed with some light elements, such as Si, S, O and C [1]. The transport properties of Fe alloys at Earth’s core conditions constrain the heat flow from the core into mantle, which governs the geodynamo, dynamics and thermal evolution of Earth’s core [2,3]. While, this property is still not well understood and remains controversial in previous work due to the experimental challenging at very high pressure and temperature [4,5]. Here, we directly measure the electrical resistivity of hcp-Fe-Ni and hcp-Fe-Si alloys at the relevant conditions of Earth’s core using double-side laser-heated Diamond Anvil Cells. Our results show a quasi-linear relation between temperature and resistivity in hcp-Fe-Ni and hcp-Fe-Si at the core pressures. Compared with hcp-Fe [6], the impurities like Ni and Si can elevate iron’s resistivity but they show different magnitude. Thermal conductivity of an Fe-Ni-Si alloy as a candidate core composition was modelled via the Wiedemann-Franz law based on our measured resistivity. Our results show that the core’s thermal conductivity could be strongly reduced by impurities, supporting a Mesoproterozoic inner core age and a self-consistent convection-driven geodynamo.

Refs:
[1] Li and Fei. Treat. Geochem., 527-557 (2014)
[2] Davies et al. Nat. Geosci. 8, 678-685 (2015)
[3] Williams. Annu. Rev. Earth Planet. Sci. 46: 47-66 (2018)
[4] Ohta et al. Nature 534, 95-98 (2016)
[5] Konôpková et al. Nature 534, 99-101 (2016)
[6] Zhang et al. Submitted, (2019)

Keywords: Fe alloys, Transport properties, High pressure-temperature, Geodynamo, Thermal evolution of the core

