The electrical resistivity of iron alloys at Earth's core conditions

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Earth generates and preserves a strong dipole magnetic field by self-sustained dynamo action in its liquid outer core for geologic timescale. Secular cooling of the core induces growth of the solid inner core that contributes additional buoyant source for the core convection. The electrical and thermal conductivities of core are two key parameters needed to determine the fundamental timescale for heat diffusion and magnetic field in the Earth's core. However, in spite of a recent large body of research, the conductivity of iron and iron alloys under Earth's core conditions is still highly controversial. For instance, recent theoretical calculations proposed conflicting values of electrical and thermal conductivity of iron [1-3].

We performed the electrical resistivity (the reciprocal of electrical conductivity) measurements on iron, iron-sulfur and iron-hydrogen alloys at high pressures (*P*) and high temperatures (*T*) in a laser-heated diamond anvil cell. Our electrical resistivity measurements on iron at Mbar pressure and at temperature up to 4500 K clearly show resistivity saturation phenomena in iron under high *P*-*T* conditions, which support recent notion of high conductivity of iron under Earth's core conditions [1] [2] [4]. Possible light elements in the core such as silicon, sulfur and hydrogen play as additional electron scatters in iron, and could result reduction of conductivity of iron. Based on our results for the resistivity measurements on iron-sulfur and iron-hydrogen alloys, we obtained impurity resistivities of sulfur and hydrogen on iron resistivity, and estimated the electrical and thermal conductivity of iron-light element alloys under core conditions. We found the impurity effects of sulfur and hydrogen were too small to reduce the conductivity of the iron alloys to the convetional value of core conductivity.

[1] de Koker *et al.* (2012) *Proc. Natl. Acad. Sci.* **109,** 4070-4073, [2] Pozzo *et al.* (2012) *Nature* **485,** 355-358, [3] Zhang *et al.* (2015) *Nature* **517,** 605-607, [4] Gomi *et al.* (2013) *Phys. Earth Planet. Inter.* **224,** 88-103.