The effect of sulfur on the electrical resistivity of iron and implications for planetary cores

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Large temperature gradient existing from Earth's core to crust induces vigorous convections in the liquid metallic outer core and solid mantle, which is a prominent source of the Earth's dynamics and thermal evolution. The electrical and thermal conductivities of core are basic physical parameters for knowing the dynamics inside the Earth. However, in spite of a large body of research, the conductivity of iron and iron alloys under Earth's core conditions is still highly controversial. Although sulfur (S) is traditionally listed as one of the most likely elements in the Earth's core in addittion to iron and nickel [1], the effect of sulfur on the iron conductivity is completely unknown.

In this study, we measured high-pressure and high-temperature electrical resistivity (the reciprocal of electrical conductivity) of iron-sulfur (Fe-S) alloy in a laser-heated diamond anvil cell (DAC). Our electrical resistivity measurements were performed at 21 and 45 GPa and at temperatures up to 2200 K where is above the eutectic temperature of the Fe-S sample we used. Thus we obtained the resistivity of solid Fe and liquid Fe-S mixture, and estimated impurity resistivity of S on iron comparing the reported values of the resistivity of iron [2]. We found the impurity resistivity of S is greater than that of silicon determined by similar DAC experiments [2] [3], indicating that the presence of sulfur in the core reduces the electrical and thermal conductivity of core much more than silicon. Since Martian meteorite geochemistry suggested sulfur-rich core of Mars [4], the obtained impurity resistivity of S on iron would have important implications for heat transport not only in the Earth's core but also in the Martian core.

[1] Poirier (1994) *Phys. Earth and Planet. Inter.* **85,** 319-337, [2] Gomi *et al.* (2013) *Phys. Earth Planet. Inter.* **224,** 88-103, [3] Seagle *et al.* (2013) *Geophys. Res. Lett.* **40,** doi:10.1002/2013GL057930, [4] Sanloup et al. (1999) *Phys. Earth Planet. Inter.* **112,** 43-54.