Geophysical Research Abstracts
Vol. 15, EGU2013-3473-1, 2013
EGU General Assembly 2013

Electrical and Thermal Conductivity of Liquid Iron and Iron Alloys at Core Conditions

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The electronic transport properties of liquid iron at conditions of the Earth's core are critical to understanding processes associated with the thermal evolution of our planet and the magnetic field generation in the liquid outer core. Until recently, values used for electrical conductivity (σ) were based on experimental results at lower temperatures and pressures, all obtained for solid phases of iron. The extrapolation to core conditions hinges on a number of assumptions, and electrical conductivity values were converted to thermal conductivity (κ) through the Wiedemann-Franz law.

Recently, we have performed ab-initio simulations [1] to compute both electrical and thermal conductivity of Fe and some iron alloys directly at conditions of the Earth's core. These simulations have the advantage that σ and κ can be computed independently, thus allowing us to test assumptions that have previously been used in experiments.

In the computations both σ and κ are found higher by a factor of ~ 3 than previously used in models of thermal evolution of the core and geodynamo simulations, with values in excess of $10^6\ \Omega^{-1}\cdot\mathrm{m}^{-1}$ and 100 $\mathrm{W}\cdot\mathrm{m}^{-1}\cdot\mathrm{K}^{-1}$, respectively. While these values appear high in light of previous extrapolations, they find support in other ab-initio simulations, previous measurements of σ in shock wave experiments, and recent static high pressure experiments in the diamond anvil cell. The high values for σ and κ raise a number of geophysical questions, especially with respect to the thermal state and evolution of the Earth's core.

[1] N. de Koker, G. Steinle-Neumann, and V. Vlčcek (2012), *Proc. Nat. Acad. Sci* **109**, 4070.