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Heat flow in the cores of Earth, Mercury and Venus from resistivity experiments on Fe-Ni-Si

meryem berrada, Richard Secco, and Wenjun Yong
The University of Western Ontario, Earth Sciences, Canada

Recent theoretical studies have tried to constrain internal structure and composition of Earth, Mercury and Venus using thermal evolution models. In this work, the adiabatic heat flow at the top of the core was estimated using the electronic component of thermal conductivity (k_{el}), a lower bound for thermal conductivity. Direct measurements of electrical resistivity (ρ) of Fe-10wt%Ni-wt%Si at core conditions can be related to k_{el} using the Wiedemann-Franz law. Measurements were carried out in a 3000 ton multi-anvil press using a 4-wire method. The integrity of the samples at high pressures and temperatures was confirmed with electron-microprobe analysis of quenched samples at various conditions. Measurements of ρ at melting seem to remain constant at 135 μΩcm and 141 μΩcm on the solid and liquid sides of the melting boundary. The heat flow at the top of Earth's CMB is greatly influenced by the light element content in the core. Interpolation of the measured thermal conductivity from this study with high pressure data from the literature suggest the addition of 10-16 wt%Ni and 3-10wt%Si in Earth core results in a heat flow of 6.8 TW at the top of the core. In Mercury, the presence of a thermally stratified layer of Fe-S at the top of an Fe-rich core has been suggested, which implies a sub-adiabatic heat flow on the core side of the CMB. The calculated adiabatic heat flux at the top of Mercury's core suggests a sub-adiabatic from 0.09-0.21 Gyr after formation, which suggest a chemically driven magnetic field after this transition. Also, the heat flow in Mercury's interior is estimated to increase by 67% from the inner core to outer core. It has been proposed that an Earth-like core structure for Venus is only compatible with the current lack of dynamo if Venus' core thermal conductivity is 100 $Wm^{-1}K^{-1}$ or more. The thermal conductivity at Venus' core conditions is estimated to range from 44-51 $Wm^{-1}K^{-1}$, in agreement with scenarios of a completely solidified core.