Thermal conductivity and Seebeck coefficient of Fe and Fe-Si alloys: Implications for variable Lorenz number

Richard A. Secco

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Thermal Conductivity and Seebeck Coefficient of Fe and Fe-Si Alloys:  
Implications for Variable Lorenz Number

Richard A. Secco, Department of Earth Sciences, University of Western Ontario,  
London, Ontario, Canada N6A 5B7

Abstract
The Wiedemann-Franz Law is often used to calculate the thermal conductivity of Fe from  
experimental measurements of the electrical conductivity. It is shown by measurements of the  
Seebeck coefficient (S) of solid and liquid Fe at pressures up to 6GPa and temperatures up to  
2100K that the Sommerfeld value \( (L_0 = 2.445 \times 10^{-8} \text{ W} \Omega^{-1} \text{ K}^{-2}) \) of the Lorenz number \( (L) \)  
represents more than 99% of the electronic component of the thermal conductivity of Fe. Using  
experimental values of electrical resistivity and thermal conductivity of Fe, \( L/L_0 \) is shown to vary  
by as much as 1.22 in the solid state and 1.32 in the liquid state, signifying a non-negligible  
phonon component. An expression for the pressure dependence of \( L \) at the melting boundary up  
to 5GPa is derived for electron-phonon scattering. For Fe-Si alloys, \( L/L_0 \) varies more than for  
pure Fe and generally increases with increasing Si and state of disorder. New values for the  
conductive heat flow in a pure Fe core of Mercury are presented.

Keywords: core heat flow; electrical resistivity; thermal conductivity; Wiedemann-Franz Law,  
iron-silicon

1. Introduction
The thermal conductivity of the Earth’s liquid metallic outer core (OC) has direct bearing on the  
growth rate of the solid inner core (IC), and therefore its age, as well as the production of the  
geomagnetic field through dynamo action. The age of the IC has been estimated to be between  
1.0-2.5Ga by energy conservation modelling (Labrosse et al 2001), 1.0-1.5Ga by an increase in  
both average geomagnetic field strength and variability (Biggin et al 2015), and as young as  
0.5Ga from models employing high thermal conductivity values calculated from measurements
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