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

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2 **Thermal Conductivity and Seebeck Coefficient of Fe and Fe-Si Alloys:**
3 **Implications for Variable Lorenz Number**
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7

8 **Abstract**

9 The Wiedemann-Franz Law is often used to calculate the thermal conductivity of Fe from
10 experimental measurements of the electrical conductivity. It is shown by measurements of the
11 Seebeck coefficient (S) of solid and liquid Fe at pressures up to 6GPa and temperatures up to
12 2100K that the Sommerfeld value ($L_0 = 2.445 \times 10^{-8} \text{ W } \Omega \text{ K}^{-2}$) of the Lorenz number (L)
13 represents more than 99% of the electronic component of the thermal conductivity of Fe. Using
14 experimental values of electrical resistivity and thermal conductivity of Fe, L/L_0 is shown to vary
15 by as much as 1.22 in the solid state and 1.32 in the liquid state, signifying a non-negligible
16 phonon component. An expression for the pressure dependence of L at the melting boundary up
17 to 5GPa is derived for electron-phonon scattering. For Fe-Si alloys, L/L_0 varies more than for
18 pure Fe and generally increases with increasing Si and state of disorder. New values for the
19 conductive heat flow in a pure Fe core of Mercury are presented.
20

21 *Keywords:* core heat flow; electrical resistivity; thermal conductivity; Wiedemann-Franz Law,
22 iron-silicon
23

24
25 **1. Introduction**

26 The thermal conductivity of the Earth's liquid metallic outer core (OC) has direct bearing on the
27 growth rate of the solid inner core (IC), and therefore its age, as well as the production of the
28 geomagnetic field through dynamo action. The age of the IC has been estimated to be between
29 1.0-2.5Ga by energy conservation modelling (Labrosse et al 2001), 1.0-1.5Ga by an increase in
30 both average geomagnetic field strength and variability (Biggin et al 2015), and as young as
31 0.5Ga from models employing high thermal conductivity values calculated from measurements

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