If we keep only the terms proportional to N we obtain:

$$\begin{aligned} -\beta F = {} & \frac{\beta J}{N}[L^2 - K^2 - S^2] - \beta \Delta \cdot n + \frac{1}{2}\beta \Delta \cdot N \\ & - \left(\frac{n - B_1}{2}\right)\log\left(\frac{n - B_1}{2}\right) - \left(N - \frac{n + B_1}{2}\right)\log\left(N - \frac{n + B_1}{2}\right) \\ & - \left(\frac{n - B_2}{2}\right)\log\left(\frac{n - B_2}{2}\right) - \left(N - \frac{n + B_2}{2}\right)\log\left(N - \frac{n + B_2}{2}\right) \\ & - \left(\frac{B_1}{2} - S_1\right)\log\left(\frac{B_1}{2} - S_1\right) - \left(\frac{B_1}{2} + S_1\right)\log\left(\frac{B_1}{2} + S_1\right) \\ & - \left(\frac{B_2}{2} - S_2\right)\log\left(\frac{B_2}{2} - S_2\right) - \left(\frac{B_2}{2} + S_2\right)\log\left(\frac{B_2}{2} + S_2\right) \\ & - \left(\frac{cN}{2} - K\right)\log\left(\frac{cN}{2} - K\right) - \left(\frac{cN}{2} + K\right)\log\left(\frac{cN}{2} + K\right) + \text{const.} \end{aligned} \tag{32}$$

For fixed K and $J > 0$ the maximum value of $-\beta F$ is

$$\begin{aligned} -\beta F(K) = {} & 2N\log\left\{\cosh\left[\beta \cdot J\frac{K}{N}\right] + \cosh\left[\frac{1}{2}\beta\Delta\right]\right\} \\ & - \left(\frac{cN}{2} - K\right)\log\left(\frac{cN}{2} - K\right) - \left(\frac{cN}{2} + K\right)\log\left(\frac{cN}{2} + K\right) + \text{const.} \end{aligned} \tag{33}$$

In the limit of large N we can take the sum on the right of Eq. (30) to be equal to its largest term.

The condition for $-\beta F$ to be an extremum with respect to K is

$$-\beta\frac{\partial F(K)}{\partial K} = 2\beta J\frac{\sinh\left[\beta \cdot J\frac{K}{N}\right]}{\cosh\left[\beta J\frac{K}{N}\right] + \cosh\left[\frac{1}{2}\beta\Delta\right]} - \log\frac{\frac{cN}{2} + K}{\frac{cN}{2} - K} = 0\,^{*}. \tag{34}$$

This equation for the magnetization $M = 2K/cN$ is identical with the one (Eq. (13)) derived with the molecular field method.

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* Note that for $J < 0$ we obtain exactly the same Eq. (34) for the magnetization, whereas THOMPSON [7], (special case $\Delta \equiv 0$) due to a mathematical error finds a different result for $J < 0$.

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An Analysis of the Temperature and Pressure Dependence of the Electrical Resistivity in Lead

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The volume dependence of the high temperature electrical resistivity has been treated in detail for lead. Volume changes caused by external pressure as well as thermal expansion have been considered. Experiments on the volume dependence of the effective electron mass have been reanalysed with an inclusion of electron-phonon interaction. Finally, we have found no experimental support for a net effect from a Debye-Waller factor and multi-phonon processes.

Die Volumenabhängigkeit des elektrischen Widerstandes von Blei bei hohen Temperaturen ist ausführlich behandelt. Volumenänderungen, hervorgerufen sowohl durch äußeren Druck als auch durch Wärmeausdehnung, wurden betrachtet. Experimente über die Volumenabhängigkeit der effektiven Elektronenmasse sind neu überprüft worden unter Einbezug der Elektron-Phonon-Wechselwirkung. Eine experimentelle Bestätigung für einen Nettoeffekt, herrührend von einer unvollständigen Kompensation eines Debye-Waller-Faktors durch Multiphonon-Prozesse, konnte nicht gefunden werden.

Nous avons calculé la résistance électrique de plomb à haute température en fonction du volume. Des changements de volume, aussi bien causés par la pression extérieure que par l'expansion thermique, ont été considérés. Nous avons réanalysé des expériences sur la variation de la masse effective de l'électron en fonction du volume, en tenant compte de l'interaction électron-phonons. Finalement, nous n'avons trouvé aucune preuve expérimentale pour un effet dû à une compensation incomplète d'un facteur de Debye-Waller et de collisions multi-phonons.

Introduction

The purpose of this paper is threefold. We will try to account for the volume (i.e. pressure) dependence of the electrical resistivity in a detailed calculation based not on models but on data from experiments on other metallic properties. Secondly, it has been conjectured that the Debye-Waller factor and multiphonon processes might cancel in the electrical resistivity and we will therefore analyse this question with the help of available experimental data. Finally we reanalyse experiments on the volume dependence of the effective electron mass and take into account the variation in the electron-phonon enhancement factor. We will consider lead, because of lack of relevant data for other elements.

Theory

There are numerous calculations in the literature [1] of the volume dependence of the electrical resistivity in metals. Although some of them are very elaborate, they make use of models and assumptions that we now know are much too crude.