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▶ **To cite this version:**

R. Fletcher, M. Stinson. THE HIGH FIELD THERMOMAGNETIC COEFFICIENTS OF POTASSIUM. Journal de Physique Colloques, 1978, 39 (C6), pp.C6-1028-C6-1030. 10.1051/jphyscol:19786454 . jpa-00217933

HAL Id: jpa-00217933

https://hal.science/jpa-00217933v1

Submitted on 4 Feb 2008

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THE HIGH FIELD THERMOMAGNETIC COEFFICIENTS OF POTASSIUM

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Résumé.- Nous présentons des résultats sur la résistivité Righi-Leduc γ_{yx} et la magnétorésistance thermique transverse γ_{xx} du potassium polycrystallin à basses températures ($1,5 \leq T \leq 4,5$ K) en champ appliqué jusqu'à 4.5 tesla. On peut comprendre nos valeurs à l'aide de la théorie semi-classique utilisant un champ élevé. Nous pouvons ainsi déterminer la conductibilité thermique du réseau avec précision.

Abstract- We present data on the Righi-Leduc resistivity γ_{yx} and the transverse thermal magnetoresistivity γ_{xx} of polycrystalline potassium for $1.5\ K \leq T \leq 4.5\ K$, and for fields up to 4.5 telsa. We find that our data can be understood within the framework of high field semi classical theory and we are able to accurately extract the lattice thermal conductivity.

Some time ago it was suggested by one of us /1/ that the lattice thermal conductivity λ_g of pure uncompensated metals (e.g. K, Cu,Al) could be obtained by studying their high field thermomagnetic properties. At high fields one expects to see a component of the transverse thermal resistivity γ_{xx} which varies approximately quadratically with magnetic field B ; the coefficient of this component depends on λ_g and the Righi-Leduc resistivity γ_{xx}. Additionally, at sufficiently high fields, one expects to find a noticeable decrease in the Righi-Leduc coefficient γ_{yx}/B, again caused by the presence of λ_g. Initial experiments /2/ aimed at demonstrating the effect were done on K at low fields (of less than 1 T) and the anticipated quadratic component of γ_{xx} was clearly in evidence. Other independent work /3/ at fields up to 1.8 T was in substantial agreement, However, the λ_g that was extracted from this data was much larger than that predicted by theory and did not exhibit the expected T^2 dependence.

More recently, Tausch and Newrock (TN) extended the experimental investigation /4/ to very high fields (∿8-10 T). Their γ_{xx} data indicate no saturation of the B^2 contribution and their values of γ_{yx}/B show only a weak decrease with B(∿ 7% at 9 T) both of these results are contrary to those which would be predicted from an extrapolation of the low field data, assuming λ_g had been correctly identified in that data. However, an examination of the TN results reveals a serious inconsistency, which makes it doubtful whether their data can be explained by any current theory . TN used the prediction /5/ of the high field semiclassical (LAK) theory in their analysis of γ_{yx}. However, if one uses their published data on γ_{xx} and γ_{yx} to obtain the thermal conductivities λ_{xx} and λ_{xy} *(these latter being the predicted quantities in the theory)*, then one finds that above about 2T, λ_{xy} departs very strongly from the predicted value of LTne/B [n is the number density of electrons, e the electronic charge, L the Sommerfeld value of the Lorenz number and T the temperature] ; e.g. by 9 T, λ_{xy} is only about 50% of the expected value. An independent investigation is clearly warranted and the purpose of this paper is to report our preliminary findings on polycrystalline K for $1.5\ K \lesssim T \lesssim 4.5\ K$ and $B \lesssim 4.5$ T. Although our maximum field is only one half of that used by TN, we note that their data indicates a 15-20% reduction of λ_{xy} below LTne/B by 4.5 T.

Figures 1 and 2 show some of our data on $\gamma_{yx}LT/B$ and γ_{xx} for a sample of K with residual resistivity ratio $(R_{293}/R_{4.2})$ of 5000: It is evident that γ_{yx}/B shows a strong decrease as B is increased, in contrast to the TN data. We have evaluated λ_{xx} and λ_{xy} using $\lambda = \gamma^{-1}$ .Figure 1 shows $LT/\lambda_{xy}B$, which should be equal to $(ne)^{-1}$ [and incidentally $1/B\sigma_{xy}$ where σ_{xy} is the Hall conductivity] *independent of the existence or otherwise of* λ_g ; within our experimental errors, these relations are accurately obeyed and their demonstration provides a self-consistency check for the data as well as confirming the LAK theory. The LAK theory further predicts that the electronic part of λ_{xx} should behave like $\alpha(T)/B^2$ at high fields, where $\alpha(T)$ depends on T but not B. With λ_g present we expect $\lambda_{xx} = [\alpha(T)/B^2] + \lambda_g$ and, although we might anticipate

Article published online by EDP Sciences and available at http://dx.doi.org/10.1051/jphyscol:19786454

finding additional B dependent terms in the final analysis (e.g. $\frac{1}{B}$), the data in figure 3 do conform reasonably well to this expression.

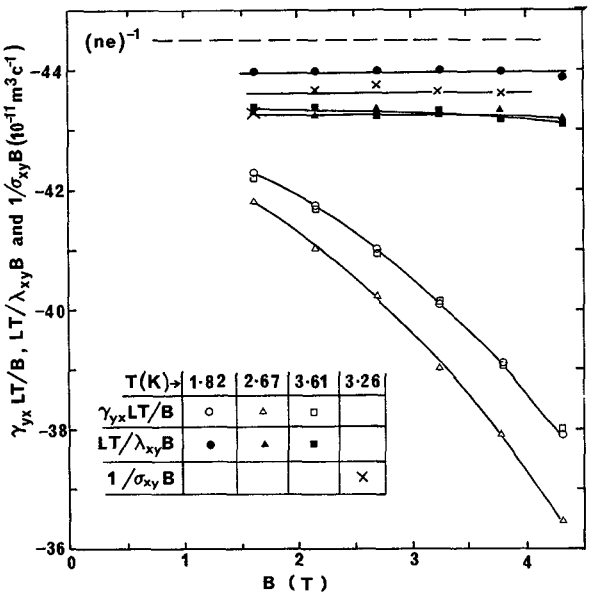

Fig.1 : γ_{yx}/B for K as a function of B for various values of T. The data has been multiplied by LT for comparison with the expected value of $(ne)^{-1}$. We have also plotted our data on LT/λ_{xy} and $1/\sigma_{xy}B$. $\lambda_{xy} = \gamma_{yx}/(\gamma_{xx}^2 + \gamma_{yx}^2)$. σ_{xy} is the Hall conductivity $= \rho_{yx}/(\rho_{xx}^2 + \rho_{yx}^2)$.

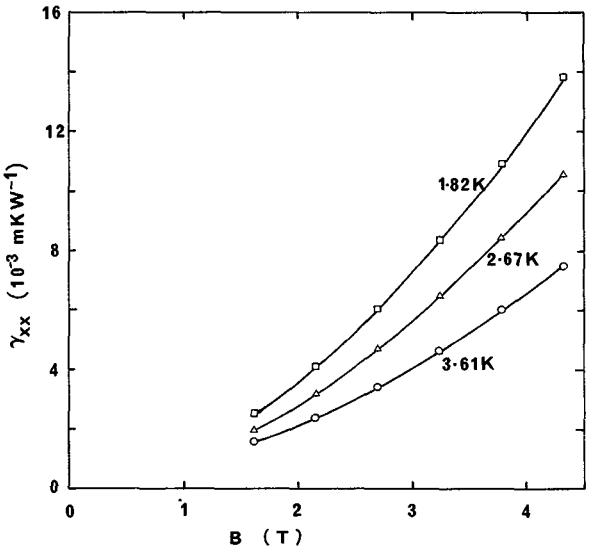

Fig.2 : The transverse thermal resistivity of K for various values of T.

We identify the intercepts with λ_g and replot them in figure 4 as a function of T. The values of λ_g so obtained are comparable with those from the initial low field estimates though the present data has a far higher precision.

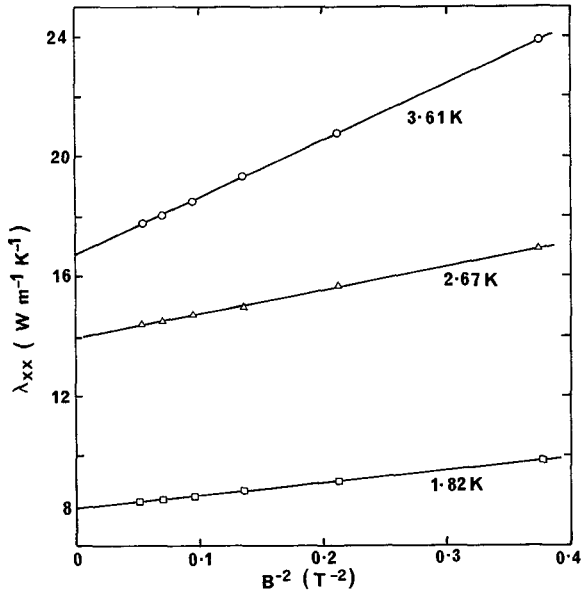

Fig. 3 : Plots of $\lambda_{xx} = \gamma_{xx}/(\gamma_{xx}^2 + \gamma_{yx}^2)$ as a function of B^{-2}.

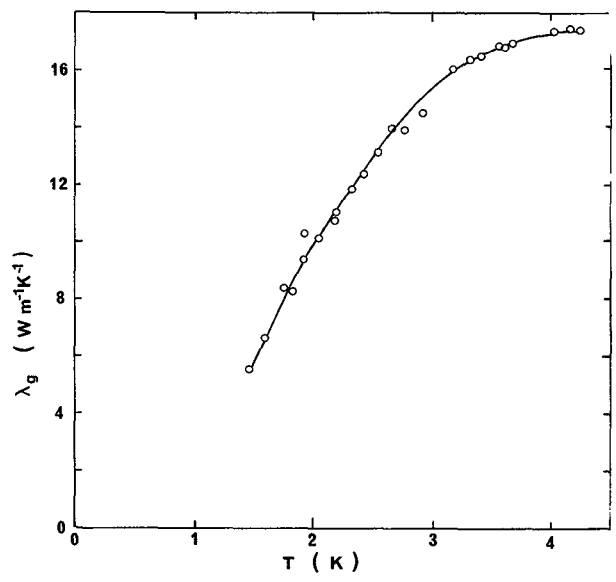

Fig.4 : The intercepts of figure 3 (and other similar results), which we indentify with λ_g, plotted against T.

We conclude that the LAK theory allows a consistent interpretation of the thermomagnetic coefficients of K to be given and enables λ_g to be obtained with reasonably high precision.

References

/1/ Fletcher,R., J. Phys. F14 (1974) 1155

/2/ Fletcher,R., Phys.Rev.Lett.32(1974) 930

/3/ Newrock,R.S. and Maxfield,B.W.,Phys.Rev. B7 (1973) 1283 ; J.Low Temp.Phys. 23 (1976) 119

/4/ Tausch,P.J. and Newrock,R.S.Phys.Rev. B16 (1977) 5381

/5/ Azbel', M.Ia.,Kaganov,M.I. and Lifshitz,I.M., Zh. Eksp.Teor.Fiz.32 (1957) 1188 [Sov.Phys.-JETP 5 (1957) 967].