



**HAL**  
open science

# THE HIGH FIELD THERMOMAGNETIC COEFFICIENTS OF POTASSIUM

R. Fletcher, M. Stinson

► **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-00217933>**

Submitted on 4 Feb 2008

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

## THE HIGH FIELD THERMOMAGNETIC COEFFICIENTS OF POTASSIUM

R. Fletcher and M.R. Stinson

*Department of Physics, Queen's University Kingston, Ontario, K7L 3N6, Canada*

Résumé.- Nous présentons des résultats sur la résistivité Righi-Leduc  $\gamma_{yx}$  et la magnétorésistance thermique transverse  $\gamma_{xx}$  du potassium polycristallin à basses températures ( $1,5 < T < 4,5$  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  $\gamma_{yx}$  and the transverse thermal magnetoresistivity  $\gamma_{xx}$  of polycrystalline potassium for  $1.5 \text{ K} \leq T \leq 4.5 \text{ K}$ , and for fields up to 4.5 tesla. 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.

Sometime ago it was suggested by one of us /1/ that the lattice thermal conductivity  $\lambda_g$  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  $\gamma_{xx}$  which varies approximately quadratically with magnetic field B; the coefficient of this component depends on  $\lambda_g$  and the Righi-Leduc resistivity  $\gamma_{yx}$ . Additionally, at sufficiently high fields, one expects to find a noticeable decrease in the Righi-Leduc coefficient  $\gamma_{yx}/B$ , again caused by the presence of  $\lambda_g$ . 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  $\gamma_{xx}$  was clearly in evidence. Other independent work /3/ at fields up to 1.8 T was in substantial agreement. However, the  $\lambda_g$  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 ( $\sim 8-10$  T). Their  $\gamma_{xx}$  data indicate no saturation of the  $B^2$  contribution and their values of  $\gamma_{yx}/B$  show only a weak decrease with B ( $\sim 7\%$  at 9 T) both of these results are contrary to those which would be predicted from an extrapolation of the low field data, assuming  $\lambda_g$  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  $\gamma_{yx}$ . However, if one uses their

published data on  $\gamma_{xx}$  and  $\gamma_{yx}$  to obtain the thermal conductivities  $\lambda_{xx}$  and  $\lambda_{xy}$  (these latter being the predicted quantities in the theory), then one finds that above about 2T,  $\lambda_{xy}$  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,  $\lambda_{xy}$  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  $1.5 \text{ K} \lesssim T \lesssim 4.5 \text{ K}$  and  $B \lesssim 4.5 \text{ T}$ . Although our maximum field is only one half of that used by TN, we note that their data indicates a 15-20% reduction of  $\lambda_{xy}$  below  $LTne/B$  by 4.5 T.

Figures 1 and 2 show some of our data on  $\gamma_{yx} LT/B$  and  $\gamma_{xx}$  for a sample of K with residual resistivity ratio ( $R_{293}/R_{4.2}$ ) of 5000: It is evident that  $\gamma_{yx}/B$  shows a strong decrease as B is increased, in contrast to the TN data. We have evaluated  $\lambda_{xx}$  and  $\lambda_{xy}$  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  $\sigma_{xy}$  is the Hall conductivity] independent of the existence or otherwise of  $\lambda_g$ ; 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  $\lambda_{xx}$  should behave like  $\alpha(T)/B^2$  at high fields, where  $\alpha(T)$  depends on T but not B. With  $\lambda_g$  present we expect  $\lambda_{xx} = [\alpha(T)/B^2] + \lambda_g$  and, although we might anticipate

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.

obtained are comparable with those from the initial low field estimates though the present data has a far higher precision.

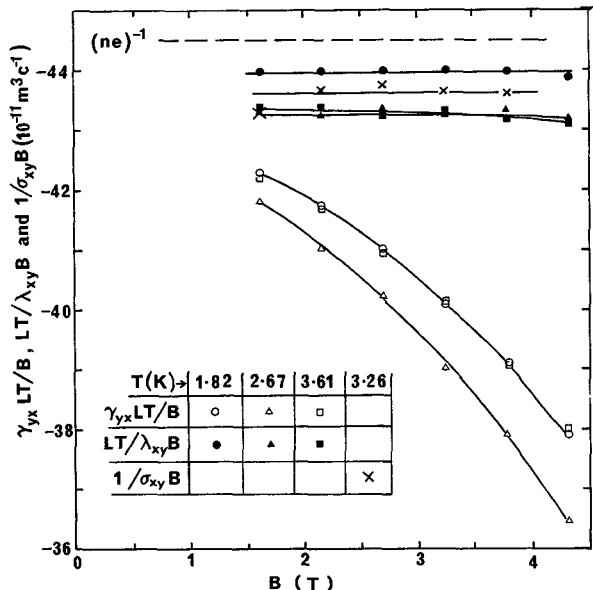


Fig.1 :  $\gamma_{yx}/B$  for K as a function of B for various values of T. The data has been multiplied by LT for comparison with the expected value of  $(ne)^{-1}$ . We have also plotted our data on  $LT/\lambda_{xy}$  and  $1/\sigma_{xy}$ .  
 $\lambda_{xy} = \gamma_{yx}/(\gamma_{xx}^2 + \gamma_{yx}^2)$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

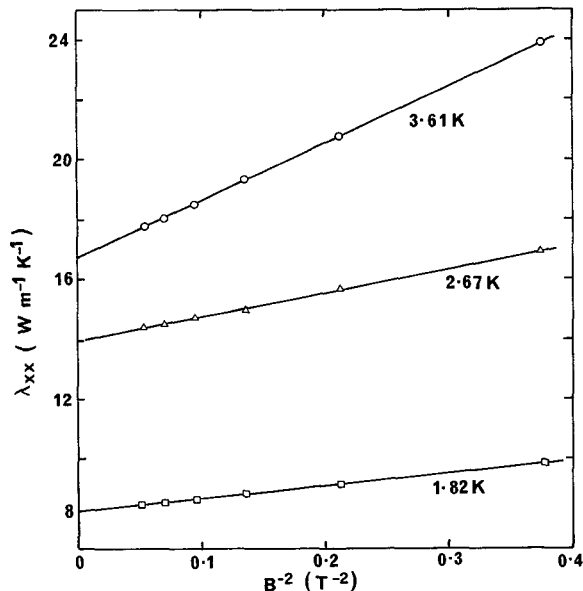


Fig. 3 : Plots of  $\lambda_{xx} = \gamma_{xx}/(\gamma_{xx}^2 + \gamma_{yx}^2)$  as a function of  $B^{-2}$ .

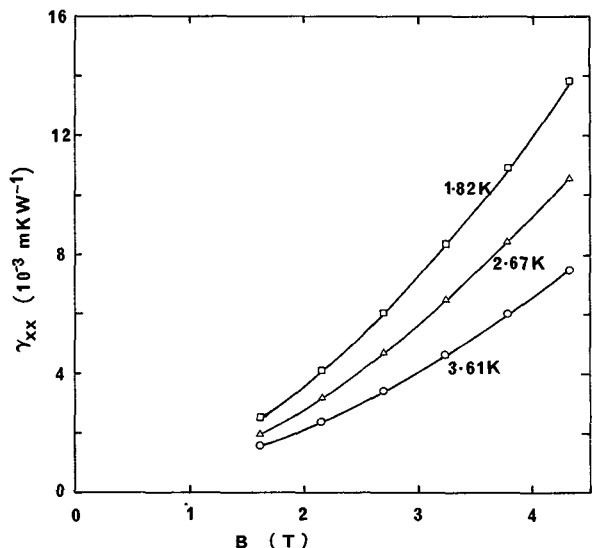


Fig.2 : The transverse thermal resistivity of K for various values of T.

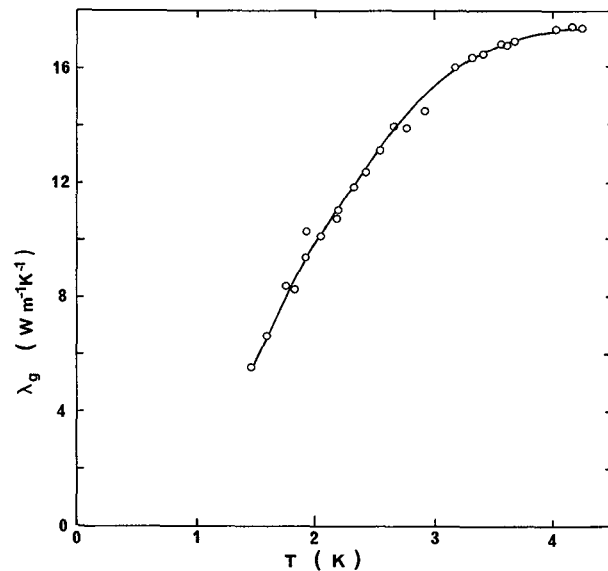


Fig.4 : The intercepts of figure 3 (and other similar results), which we identify with  $\lambda_g$ , plotted against T.

We identify the intercepts with  $\lambda_g$  and replot them in figure 4 as a function of T. The values of  $\lambda_g$  so

We conclude that the LAK theory allows a consistent interpretation of the thermomagnetic coefficients of K to be given and enables  $\lambda_g$  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.TeorFiz.32 (1957) 1188 [Sov.Phys.-  
JETP 5 (1957) 967].