acta phys. slov. 31. (1981), No. 2—3

TRANSPORT PROPERTIES OF $PrNi_5$ AT LOW TEMPERATURES[1]

ТРАНСПОРТНЫЕ СВОЙСТВА $PrNi_5$ ПРИ НИЗКИХ ТЕМПЕРАТУРАХ

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In the present contribution the temperature dependence of the electrical resistivity, longitudinal magnetoresistance and thermal conductivity of $PrNi_5$ are investigated. In the electrical resistivity at a temperature around 15 K a slight anomaly indicating the crystal-field effect on the resistivity has been observed. The magnetoresistance up to 7 T is positive without a tendency to saturation. The thermal conductivity shows a linear temperature dependence in the temperature range of 0.5—8 K.

RNi_5 intermetallic compounds (R standing for any rare-earth element) have recently attracted much attention mainly due to prospects for using $LaNi_5$ in the hydrogen storage technology and due to the successful application of $PrNi_5$ in the method of hyperfine enhanced nuclear cooling. RNi_5 compounds crystallize in the hexagonal $CaCu_5$ structure. Except for $PrNi_5$, all RNi_5 compounds are ferromagnetic or antiferromagnetic at low temperatures (27 K is found to be the highest ordering temperature). Since the 3*d* shell of nickel ions in RNi_5 seems to be filled by the valence electrons of the rare-earth ions, the magnetic order in these compounds is due to the ordering of the rare-earth moments. On the other hand from measurements of the specific heat [1—3] and the magnetic susceptibility [2], [4] it is known that $PrNi_5$ is a paramagnetic substance. From these works it also follows that in $PrNi_5$ the exchange interaction, which could induce long range magnetic order, is much weaker than that of the crystal field and the crystal-field ground state is a singlet, which leads to Van Vleck paramagnetism at low temperatures.

However, so far only few data are known on the transport properties of RNi_5 compounds and especially of $PrNi_5$.

The measurements pressented in this paper were performed on a cylindrical polycrystalline sample of approximately 6 mm diameter × 5 cm, prepared in the Ames Laboratory (USA). The residual resistivity ratio (RRR), $\varrho_{300}/\varrho_{4.2}$ = 23. The electrical resistance was measured potentiometrically by the four-terminal method. For determination of the thermal conductivity a steady-state axial heatflow method was used. The absolute error of the thermal conductivity data was 5 %.

The measured electrical resistivity of $PrNi_5$ between 1.5 and 25 K is plotted in Fig. 1. Extrapolating the experimental curve below 4.2 K the residual resistivity ϱ_0 = 4.18 μΩ cm was determined. In the temperature range 8—15 K the slope of the electrical resistivity may be described by the relation $\varrho \sim 0.211\ T$. Above 15 K a slight change of the slope is observed and the temperature dependence of the electrical resistivity can be described by the relation $\varrho \sim 0.185\ T$. The change of the slope in the

[1] Contribution presented at the 6[th] Conference on Magnetism in Košice, September 2—5, 1980.

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resistivity is in the temperature range where the susceptibility maximum in $PrNi_5$ was observed [2], [4] and was suggested by Craig et al. [2]. According to them a decline in the resistivity is anticipated at temperatures corresponding to substantial depopulation of the first excited state of the Pr ions in favour of the singlet state. This should occur between 10 and 20 K and indicates the crystal-field effect in the electrical resistivity. In the work of Craig et al. [2] the change of the slope was not observed probably because of less purity in the $PrNi_5$ sample (RRR = 2.9).

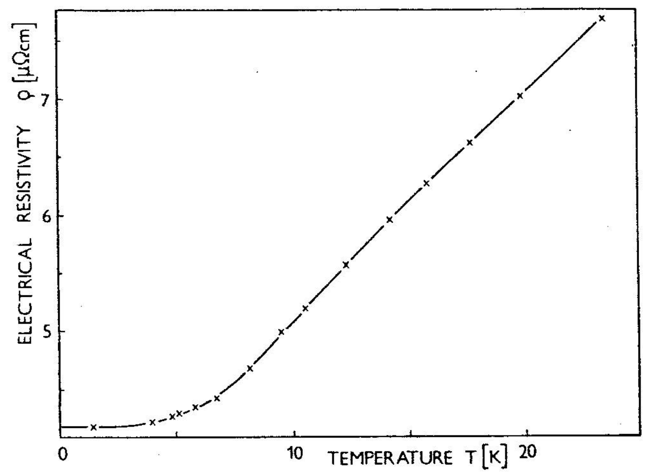

Fig. 1. Temperature dependence of the electrical resistivity of $PrNi_5$.

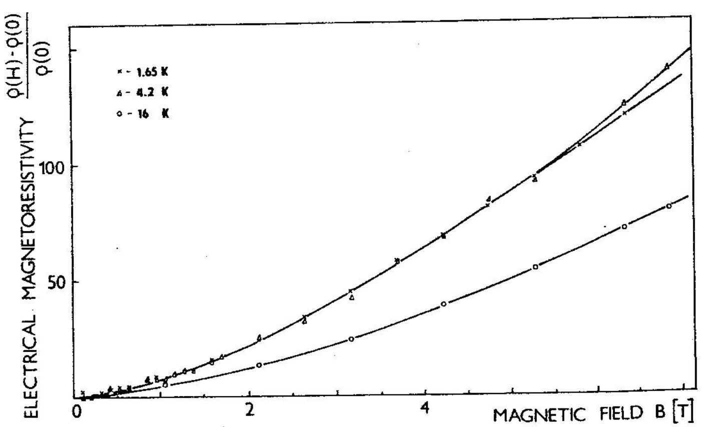

Fig. 2. Electrical magnetoresistance of $PrNi_5$.

The longitudinal magnetoresistance of $PrNi_5$ at temperatures 1.6; 4.2 and 16 K is shown in Fig. 2. The observed magnetoresistance up to 7 T is positive without a tendency to saturation. As may be seen from the figure, the quadratic dependence of the magnetoresistance below 3 T changes to a linear dependence above 3 T. The influence of the magnetic field on the electrical resistivity decreases towards higher temperatures.

The thermal conductivity data in the temperature region from 0.5 up to 8 K are displayed in Fig. 3 and can be expressed in the form $K = 0.907\ T$. The Lorenz function $L = K\varrho/T$ at 4.2 K has a magnitude of approximately $3.83 \times 10^{-8}\ W\Omega K^{-2}$. This suggests that the electronic part is the dominant contribution to thermal conductivity in the measured temperature range, and that the lattice imperfections seem to be main scattering mechanism of the heat transport.

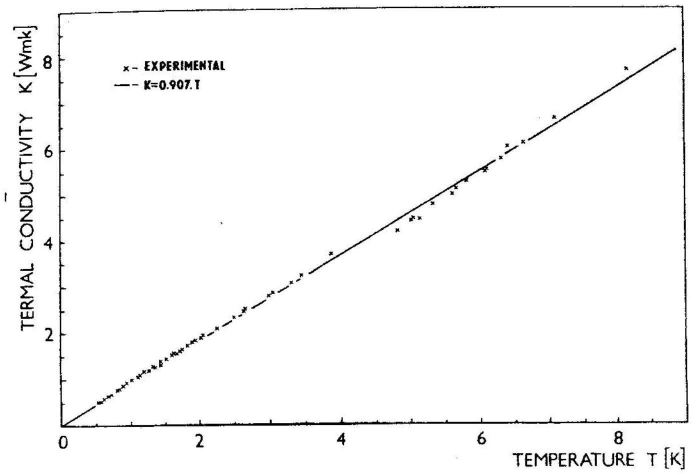

Fig. 3. Thermal conductivity of $PrNi_5$. The solid line presents the function $K = 0.907$ T.

ACKNOWLEDGEMENTS

The authors would like to thank Dr. G. Eska from the Zentralinstitut für Tieftemperaturforschung der Bayerischen Akademie der Wissenschaften in Garching for lending the sample and to Dr. Š. Jánoš for his support and stimulating discussions.

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Received October 20th, 1980