THE INFLUENCE OF THE MAGNETIC FIELD ON THE ELECTRONIC CONTRIBUTION TO THE SPECIFIC HEAT OF THULIUM[1])

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The specific heat of the thulium has been measured between 2.5 and 10 K. The electronic specific heat constant $\gamma = 14.41$ mJ/mol K^2. The coefficient γ has changed by 30 % due to the influence of the applied magnetic field 3 T.

The magnetic contribution in the temperature range from 2 K to 10 K was estimated as $C_M = 2.96\ T^{2.6}$ Mj/mol K, changed due to the influence of the magnetic field to $C_M = 3.62\ T^{2.42}$ mJ/mol K.

ВЛИЯНИЕ МАГНИТНОГО ПОЛЯ НА ЭЛЕКТРОННУЮ УДЕЛЬНУЮ ТЕПЛОЕМКОСТЬ ТУЛИЯ

В работе на основе измерения температурной зависимости поликристалличес-кого тулия определена электронная удельная теплоемкость $\gamma = 14{,}41$ мДж/моль . K^2 в диапазоне 2,5 – 10 K, которая в присутствии магнитного поля уменьшается на значение $\gamma = 10{,}75$ мДж/моль . K^2. Магнитная часть общей теплоемкости в этом диапазоне температур определяется величиной $C_M = 2{,}96\ T^{2{,}6}$ мДж/моль . K, а в магнитном поле с индукцией 3T величиной $C_M = 3{,}62\ .\ T^{2.42}$ мДж/моль . K.

I. INTRODUCTION

Due to its physico-chemical properties thulium belongs to the lanthanides. It crystalizes in a hexagonal close-packed lattice (hcp). Its basic physical properties are given in [1, 2].

The specific heat of thulium was measured by a number of authors [3, 4, 5], but their results differ by more thau 20 %. This discrepancy has not been fully explained yet, but it seems that the observed difference may be caused by the different quality of samples or by thermal cycling.

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Thulium has a surprisingly high specific heat. The magnetic contribution to specific heat probably exists also at low temperatures, due to a low temperature of magnetic transition (56 K). In [4] the magnetic contribution was separated from the observed specific heat ant found to be

$$C_M = 8.3\ T^{2.3}\ [\mathrm{mJ/mol\ K}]. \qquad (1)$$

However, this separation was not carried out very exactly. For electrons and lattice contribution the values extrapolated from those for lanthanum and lutenium were used, with $\gamma = 10.5$ mJ/mol K^{-2} and $\Theta_D(0) = 210$ K. Even when the lanthanides crystallize in a hcp structure with similar lattice parameters and a similar electronic structure, it is necessary to use values of γ and $\Theta_D(0)$ obtained from other physical measurements.

II. RESULTS AND DISCUSSION

The thulium sample was produced by Giredmet, USSR; its purity was 99.8 % and its mass 15.93 g. The specific heat was measured in a temperature range from 2 K to 10 K and in a magnetic field of 3 T by a quasiadiabatic pulse method with an accuracy of ±1 % [6, 7].

The observed temperature dependence of the specific heat of thulium in a zero magnetic field is shown in Fig. 1 and that in the magnetic field of 3 T is shown in Fig. 2. These dependences show no anomalies. For the separation of the lattice contribution the value of $\Theta_D(0) = 200$ K was taken from the measurements of elastic constants [8], whereas the value of nuclear contribution was taken from [4] as

$$C_N = 23.43\ T^{-2} \quad [\mathrm{mJ/mol\ K}]. \qquad (2)$$

Our aim was to determine the coefficients for both the electronic and the magnetic contribution to the specific heat and the possible influence of the magnetic field on their value. It follows from theory that

$$C_E + C_M = C_P - C_L - C_N. \qquad (3)$$

In the range from 2 K to 4 K, where there holds that $\Theta_D(0) = \mathrm{const}$, the measured values were fitted by the polynomial

$$C_P = 14{,}41\ T + 0.243\ T^3 + 1.88\ T^3 + 23.43\ T^{-2} \qquad (4)$$

for measurements without the magnetic field Fig. 1b and by polynomial

$$C_P = 10.75\ T + 0.243\ T^3 + 1.74\ T^3 + 23.43\ T^{-2} \qquad (5)$$

for measurements in an applied field of 3 T (Fig. 2b).

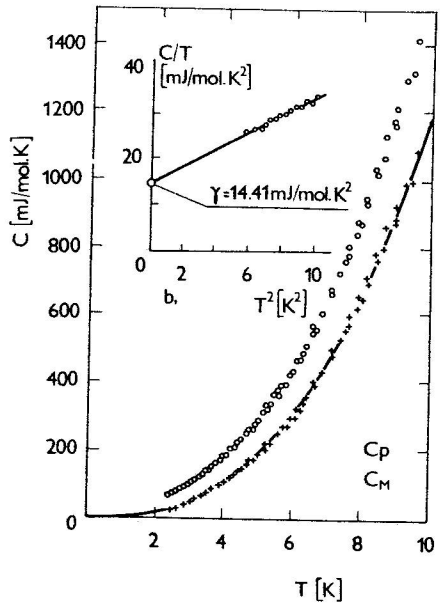

Fig. 1. Temperature dependence of the specific heat of thulium $C_P(\mathrm{O})$ and the magnetic contribution $C_M(+)$ without the magnetic field.

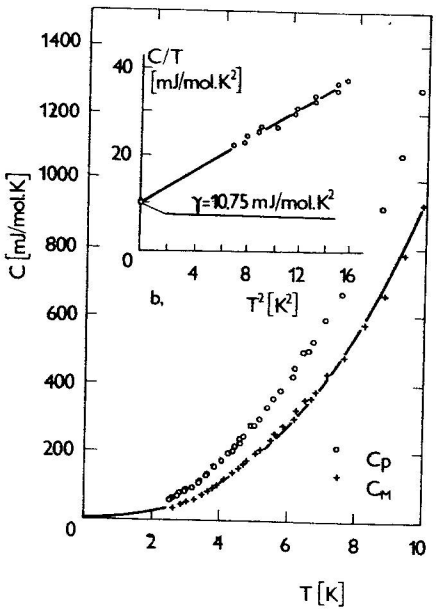

Fig. 2. Temperature dependence of the specific heat of thulium $C_P(\mathrm{O})$ and the magnetic contribution $C_M(+)$ in the magnetic field 3 T.

The coefficient γ has changed by 30 % due to the influence of the applied magnetic field 3 T. Such a change was theoretically derived in [9] and observed in Pd [10] and $LuCo_2$ [11].

The magnetic contribution C_M in the temperature range from 3 K to 10 K was determined by separation of other contributions from the total specific heat as

$$C_M = C_P - C_E - C_L - C_N. \qquad (6)$$

In the temperature range from 3 K to 10 K the set of measured values was fitted — using the least squares method — by the dependence

$$C_M = B\ .\ T^n. \qquad (7)$$

For measurements without the magnetic field the values $B = 2.96$ and $n = 2.6$ were obtained. Due to the influence of the magnetic field these coefficients changed to $B = 3.62$ and $n = 2.42$. The values of the magnetic contributions are in agreement with measurements in [4].

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