In conclusion, the authors thank G. E. Karstens and A. A. Grigor'ev for help with the work, and all the laboratory members who helped with the numerous measurements.

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INVESTIGATION OF THE THERMAL CONDUCTIVITY OF FERROMAGNETIC $CrBr_3$

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Submitted 3 October 1968
ZhETF Pis. Red. 8, No. 11, 656-658 (5 December 1968)

This paper is devoted to a study of the thermal conductivity of the ferromagnetic dielectric $CrBr_3$ at helium temperatures.

The $CrBr_3$ crystal has an hexagonal structure. It becomes ferromagnetic below a temperature $T_c = 37°K$ [1], and the hexagonal axis is the easiest-magnetization axis.

The method of preparing the single crystals used in the investigation is similar in

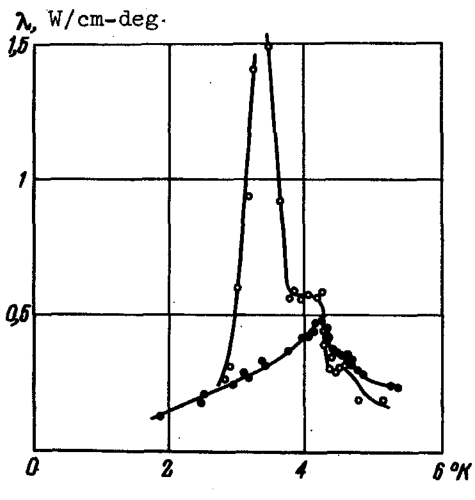

Fig. 1. Thermal conductivity vs. temperature for samples I and III: o - sample I (80 μ thick), • - sample III (50 μ thick).

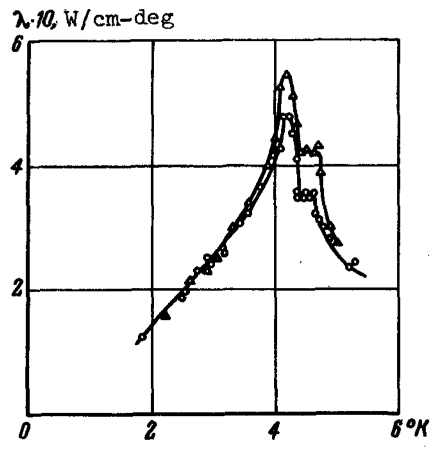

Fig. 2. Thermal conductivity vs. temperature for samples II and III: Δ - sample II (55 μ thick), o - sample III (50 μ thick).

general outline to that described in [1]. The single crystals, grown by "evaporation" of chromium powder in an atmosphere of bromine at a temperature ~750°C, were plates ~50 - 100 μ thick. The hexagonal axis in all the x-ray investigated samples was perpendicular to the plane of the plate. The chemical composition of the samples did not differ from stoichiometric.

The thermal conductivity was measured by the method of constant heat flux. The temperature gradient was directed along the plate, i.e., perpendicular to the hexagonal axis. The temperature was measured with thermometers cut from Allen-Bradley resistors (see [2] for the method of preparation). The thermometers, as well as the heaters wound of constantan wire, were glued to the sample with BF-4 glue. The measurements were made in a zero magnetic field.

We investigated three samples, 80, 55, and 50 μ thick (samples I, II, and III, respectively). The measurement results are shown in Figs. 1 and 2. As seen from the plots, when the temperature is lowered (within the measurement range) the thermal conductivity of the samples increases monotonically, reaching a maximum at $T = T_{max}$ (we note that $T_{max} \sim T_c/10$), and then decreases quite rapidly. The maximum value of the thermal conductivity coefficient λ and the temperature T_{max} depend strongly on the sample thickness. The nonmonotonic character of the $\lambda(T)$ dependence at temperatures $T > T_{max}$ was manifest in the presence of "steps": one for samples II and III (Fig. 2) and two for sample I (Fig. 1).

The character of such a behavior of the thermal conductivity can be understood qualitatively within the framework of a model first proposed by Gurzhi (see, e.g., [3]). At helium temperatures in the case of $CrBr_3$, the spin-wave specific heat exceeds by almost one order of magnitude the phonon specific heat [4]. Therefore heat transport in this region is apparently realized essentially by the spin waves. Consequently, the cause of the experimentally observed behavior of the thermal conductivity may be Umklapp processes occurring in collisions between the spin waves. In this case, the nonmonotonic dependence of the thermal conductivity at temperatures $T > T_{max}$ may be possibly due to the appearance of several anharmonicities of higher order [3].

In conclusion, it should be noted that for a final explanation of this phenomenon it is necessary to study further samples of different thickness in strong magnetic fields, which probably will make it possible to separate the magnon and phonon contributions to the total specific heat of the substance.

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