the gap becomes comparable with the operating frequency.

The discontinuous character of the transition induced in the hematite by an external magnetic field perpendicular to the easy axis of the crystal between the phases "$l_z \neq 0$" and "$l_z = 0$" can be explained, for example, by taking into account the "second anisotropy constant" [11,13]. Other interactions of order higher than the second can also lead in principle to a jump of the transition between phases [14], but a comparison of their relative role in the concrete case of hematite calls for a special investigation.

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ANOMALOUS SIGN OF THE MAGNETOCALORIC EFFECT IN FERRITES IN THE REGION OF THE COMPENSATION POINT

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There are only three published papers [1-3] reporting measurements of the magnetocaloric effect ΔT(H) in ferromagnets. Yet a study of this effect in ferrites is of considerable interest; since the ΔT(H) effect is an "energy" characteristic of a magnet, its measurement can yield useful information on the manifestation of complicated magnetic-sublattice interactions in ferrites.

We measured the ΔT(H) effect in the iron garnet $Gd_3Fe_5O_{12}$ and in the ferrite-spinel $Li_2O \cdot 2.5Fe_2O_3 \cdot 2.5Cr_2O_3$ in a wide interval of temperatures. The ferrite samples were spherical with 5 mm diameter. The hot junction of a copper-constantan thermocouple was inserted in a narrow cut in the sphere. The temperature change ΔT following the adiabatic application of the magnetic field was registered with a potentiometer setup with an amplifier having a sensitivity 0.5×10^{-3} deg. The sample was placed in an evacuated glass ampoule on which a bifilar heating element was wound; the entire setup was placed between the poles of an electromagnet.

Figure 1 shows the measurement results for the gadolinium iron garnet. We see that near the Curie temperature θ_f there is a characteristic positive maximum of ΔT, due to the paraprocess. We see further that with decreasing temperature the sign of ΔT becomes negative, and a small negative maximum is observed at the compensation point θ_c; after passing through the compensation temperature, ΔT again becomes positive.

Thus, in a certain temperature interval above θ_c, adiabatic application of the field produces not heating, as is usual for ferromagnets in the paraprocess (Co, Ni), but cooling of the sample.

The appearance of an anomalous sign of the magnetocaloric effect in the investigated iron garnet in the region $\theta_c < T < \theta_f$ is in our opinion due to the following cause:

A characteristic feature of ferrites possessing compensation points is that an intense paraprocess takes place in them in the entire interval of existence of magnetic-ordering temperatures (and not only near the Curie point). This intense paraprocess is due to the orientation of the magnetic moments of the ions situated in a sublattice in which the magnetic order is produced by a relatively weak exchange field. In the case of an iron garnet, such a sublattice is the sublattice c, in which the rare-earth ions are situated, in our case Gd^{3+}. These ions are acted upon by an effective exchange field $-H_{exch}$, of the order of 300 kOe, produced by the iron sublattices [4]. Since the magnetic moments of Gd^{3+} ions are large, even application of an external field of ~ 20 kOe gives rise to the susceptibility of the paraprocess, which is comparable in magnitude with the susceptibility of the paraprocess in the region of the Curie point, where it reaches a maximum. Accordingly, the magnetocaloric effect ΔT in this ferrite will be comparable in magnitude with the ΔT effect in the region of the Curie point. At temperatures $T < \theta_c$ the ΔT effect should be positive, since the internal

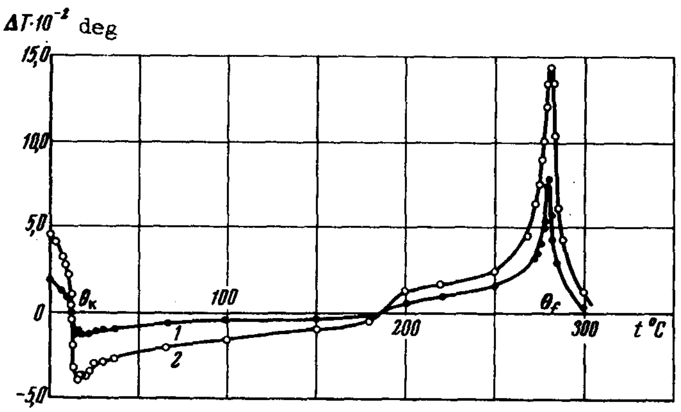

Fig. 1. Magnetocaloric effect in gadolinium iron garnet $Gd_3Fe_5O_{12}$. 1 - 6.6 kOe; 2 - 16 kOe.

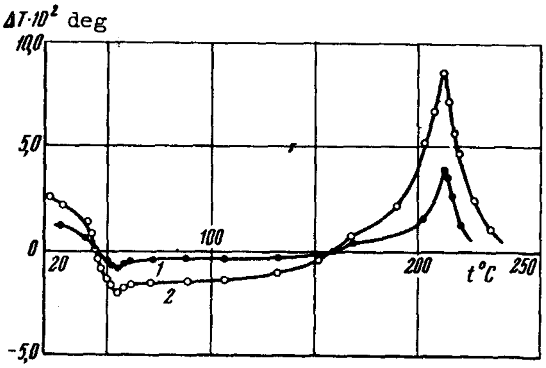

Fig. 2. Magnetocaloric effect in the ferrite $Li_2O{\cdot}2.5Fe_2O_3{\cdot}2.5Cr_2O_3$. 1 - 6.6 kOe; 2 - 16 kOe.

field is parallel in this case to the exchange field H_{exch}, as is indeed seen in Fig. 1. The situation here is the same as in normal ferromagnets: the paraprocess occurs in the presence of parallel arrangement of the vectors $\vec{H}$ and $\vec{H}_{exch}$. In this temperature region the magnetic moment of the gadolinium sublattice is larger than the magnetic moment of the iron sublattice, and the vector of the resultant magnetization is directed along the magnetic moment of the gadolinium sublattice, i.e., along the exchange field of the iron sublattices, which acts on the Gd^{3+} ions. Therefore the rotation of the magnetic moments of the Gd^{3+} ions, which are disoriented by the thermal motion, in the external (and in the field H_{exch}) is accompanied by release of heat.

In the temperature interval $\theta_c < T < \theta_f$ the external field $\vec{H}$ is antiparallel to $\vec{H}_{exch}$. In this temperature region, owing to the decrease of the magnetic moment of the gadolinium sublattice, the vector of the resultant magnetization is directed opposite to the magnetic moment of the sublattice c. This results in a paraprocess of the antiferromagnetic type - the orientation of the magnetic moments of the Gd^{3+} ions by the external field in a direction opposite to the field $\vec{H}_{exch}$. Corresponding to this process is a negative ΔT [5], as is indeed seen in Fig. 1.

Thus, in gadolinium iron garnet the sign and the character of the magnetocaloric effect are determined, in a wide temperature interval, by the paraprocess in the gadolinium sublattice: by a paraprocess of a "ferromagnetic" type in the region $T < \theta_c$ and of an "antiferromagnetic" type in the region $T > \theta_c$. In the region of the Curie point, as shown by our experiments [6], a superposition takes place of both types of paraprocesses (ferromagnetic due to the Fe ions and antiferromagnetic due to the Gd ions). The resultant magnetocaloric effect in the region of the Curie temperature has in this case a positive sign, since the resultant magnetization of the iron sublattice is larger here than that of the gadolinium sublattice.

It was found in [7] that for lithium ferrite-chromite, which has a compensation point, $\Delta R_{\parallel}/R$ and $\Delta R_{\perp}/R$, measured in fields $\sim 10^4$ Oe, have in the region $\theta_c < T < \theta_f$ identical (positive) signs. This is an anomaly, since in the paraprocess $\Delta R_{\parallel}/R$ and $\Delta R_{\perp}/R$ are always negative in ordinary ferromagnets. It is now clear to us that the anomalous signs of $\Delta R_{\parallel}/R$ and $\Delta R_{\perp}/R$ in this ferrite are due to a paraprocess of the antiferromagnetic type.

Figure 2 shows plots of $\Delta T(t)$ obtained in the present investigation for the ferrite $Li_2O \cdot 2.5Fe_2O_3 \cdot 2.5Cr_2O_3$. We see that the character of the curves on Fig. 2 is the same as on Fig. 1. It is clear that in the region $\theta_c < T < \theta_f$ the negative sign of ΔT in this ferrite is due to the paraprocess of the antiferromagnetic type. The role of the gadolinium sublattice is played here by the octahedral sublattice which contains besides the Fe^{3+} ions also the Cr^{3+} ions. It should be noted that the negative sign of ΔT in the region $\theta_c < T < \theta_f$ was observed in [3] for the spinel-ferrite $NiFeCrO_4$, but it was not interpreted there.

In conclusion we indicate that a negative ΔT can produce rotation of the ferromagnetism vector $-I_s$ against the forces of the magnetic anisotropy [8,9] and the gradients of the magnetic inhomogeneities. The ΔT effect due to the rotation of I_s is always much smaller in magnitude [8]. It can make the most noticeable contribution near θ_c, for the rotation of I_s is strongly hindered when this temperature is approached, as is evidenced by the strong growth of the coercive force in the region of θ_c [10]. It is possible that the small increase of ΔT (of negative sign) observed near θ_c (Fig. 1) is due to this cause.

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KONDO EFFECT AND SUPERCONDUCTIVITY

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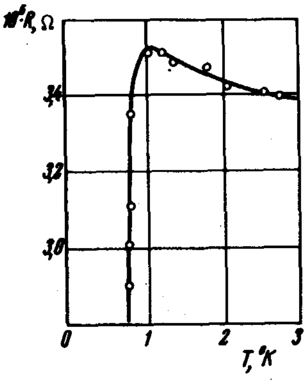
A recent paper [1] considers theoretically the interaction of conduction electrons with paramagnetic impurities in a superconductor.

One of the results of that paper is the statement of the possible coexistence of superconductivity and of the Kondo effect, which leads to the appearance of a minimum in the temperature dependence of the electric resistance.

Since the results of [1] are of basic significance in the understanding of possible factors affecting the superconductivity mechanisms, it is of interest to verify the foregoing statement experimentally.



We measured the electric resistance of molybdenum single crystals with very low iron impurity content (~2×10^{-4}%) in the temperature region 0.38 - 2.3°K (the low temperatures were obtained with the liquid He^3 apparatus designed by the authors of [2]). The measurement results are shown in the figure.

An increase of the electric resistance and a decrease of the temperature are observed up to the transition into the superconducting state. We did not study the inflence of the impurity concentration on the superconducting-transition temperature. This is treated in [3], where an accurate determination was made of T_c