RELAXATION ABSORPTION OF ELECTROMAGNETIC ENERGY IN THE ANTIFERROMAGNETIC SUBSTANCE $CoCl_2$

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The absorption of electromagnetic energy in a single crystal of the antiferromagnet $CoCl_2$, which has a Curie point at 25° K, was investigated at a frequency of 37 300 Mc/sec in magnetic fields up to 6 koe.

THE antiferromagnet $CoCl_2$ has a rhombohedral lattice. Thorough neutron diffraction investigations[1] have shown that the magnetic moments of the Co^{++} ions of each sublattice are located in alternate planes, which are perpendicular to the three-fold axis C_3. The weak anisotropy of the molecular field in each of these planes leads to the formation of antiferromagnetic domains. However, in external fields greater than 1.5 koe directed perpendicular to the C_3 axis the antiferromagnet consists of a single domain.

The monocrystals studied in the present work were grown in vacuum from a melt of preliminarily dehydrated salt. The samples obtained were transparent, homogeneous, and bluish in color. Orientation and quality of the different specimens were controlled by x rays.

The energy absorbed in the sample was determined from the power transmitted through a resonator in which the sample was placed. The transmitted power was registered on a peak-reading voltmeter, whose reading was inversely proportional to the square of the power absorbed by the sample. To prevent changes in the natural frequency of the resonator from affecting the results of the measurements, the generator frequency was modulated with a period of 0.03 sec within limits exceeding the range of resonator frequency change.

The results obtained for two orientations of the samples are presented in Figs. 1, 2, and 3.

From Figs. 1 and 2 it is seen that at a certain temperature and corresponding value of constant magnetic field H the absorbed power is at a maximum. Common to both cases is the disappearance of a non-monotonic temperature dependence of the absorbed power in fields greater than 5.5 koe.

As can be seen from Fig. 3, the power absorbed by the antiferromagnet in the paramagnetic state

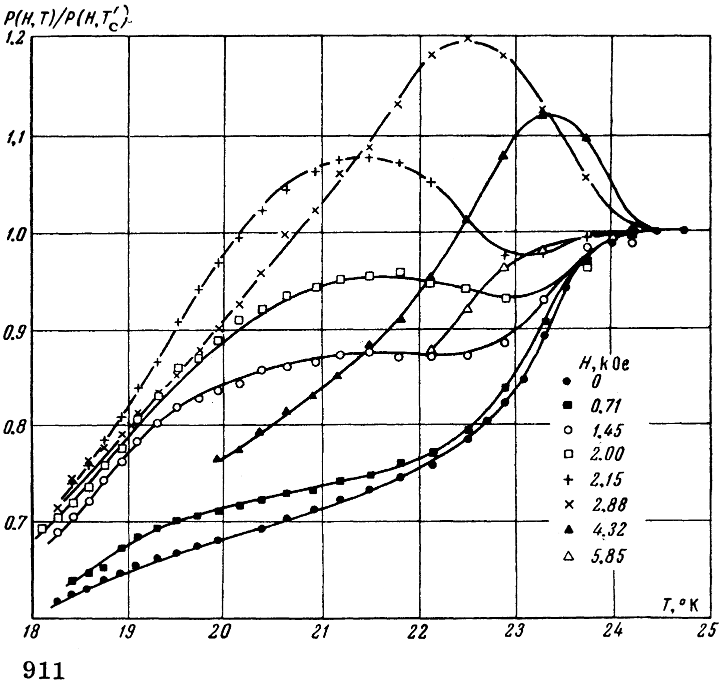

FIG. 1. Ratio of the power absorbed by a monocrystal of $CoCl_2$ at temperature T to that absorbed at $T'_C = 26°K$, $P(H, T)/P(H, T'_C)$, for various values of the constant field H. The C_3 axis of the crystal, the alternating field H', and the constant field H are mutually perpendicular.

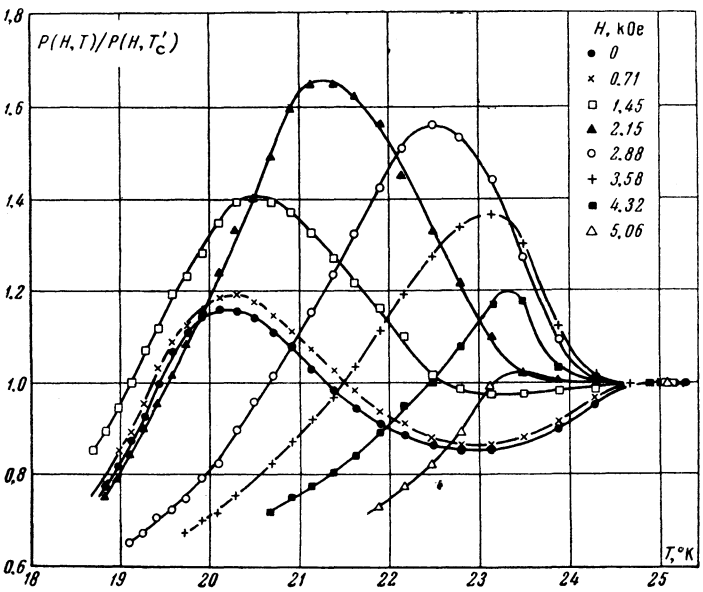

FIG. 2. Ratio of the power absorbed by a monocrystal of $CoCl_2$ at temperature T to that absorbed at $T'_C = 26°K$, $P(H, T)/P(H, T'_C)$, for various values of the constant field H. The crystal axis was parallel to the alternating field H′ and perpendicular to the constant field H.

decreases with an increase in the constant field. A similar phenomenon has also been observed[2] in paramagnetic salts. In the latter case it is associated with the existence of spin-spin and spin-lattice relaxation in the paramagnet.[3]

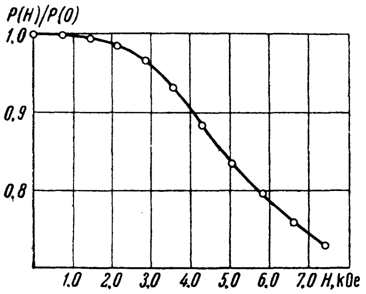

FIG. 3. Ratio of powers P(H)/P(0) absorbed by a monocrystal of $CoCl_2$ at a given field H and at H = 0 at 25.5°K. The orientation of the crystal with respect to the alternating and constant fields is the same as that of Fig. 2.

No temperature dependence of power absorbed by the sample was observed above the Curie point in the interval 25 — 40° K. However, further increase in temperature up to 80° K results in a decrease of absorption in the monocrystal.

The data presented above suggests a relaxation mechanism for the observed absorption. The relaxation processes that establish equilibrium in the spin system of the antiferromagnet can be characterized by a certain time τ. Since τ increases as the temperature of the antiferromagnet is decreased,[4,5] and the relaxation absorption of electromagnetic energy of frequency ω has the form

$$P(\omega,\tau) \sim \omega\tau/[1 + (\omega\tau)^2],$$

the magnitude of P goes through a maximum as $\omega\tau \sim 1$. Unfortunately, the dependence of P on the magnitude of the constant field has not been studied theoretically.

Experiments were also carried out with the antiferromagnet $CoBr_2$, which has a Curie point at 18° K and a structure analogous to that of $CoCl_2$. The data obtained with a sample of $CoBr_2$ with the same orientation as that of Fig. 2 were completely similar to those obtained for $CoCl_2$.

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