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Abstract

Full Text

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PARAMAGNETIC RESONANCE OF MANGANESE SULFIDE OVER A WIDE TEMPERATURE RANGE

Theoretical consideration of the phenomenon of antiferromagnetic resonance was initially carried out for uniaxial antiferromagnets within the framework of the molecular-field model ([1,2]). According to the resonance conditions obtained in these works, antiferromagnets with a Néel temperature $T_N \sim 100^\circ$ K, by a rough estimate ([3]), have a resonance frequency $\nu \sim 3 \cdot 10^5$ Mc/s, i.e., almost

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beyond the limits of frequencies attainable with modern microwave apparatus. For the frequencies practically accessible at present, magnetic fields $H_0 \sim 10^5$ oersted are required.

Uniaxial antiferromagnets are of the greatest interest for theory. However, the latter have too high values of T_N, and therefore the difficulties noted above limit experimental investigations of antiferromagnetic resonance.

Some information has been obtained from studies of the resonance of such antiferromagnets during the transition from the paramagnetic state to the antiferromagnetic state ([4–7]). However, for one and the same class of substances the results of works ([4,5]) are contradictory. It is of definite interest to clarify the reasons for this discrepancy, since the considerable resonance absorption observed in work ([4]) below the transition point T_N may be of a fundamental nature.

Fig. 3 graph

Figure 3: Fig. 3 graph

Fig. 4 graph

Figure 4: Fig. 4 graph

In the present work the resonance in powdered MnS was investigated over the temperature interval from +100 to −195° at a frequency of 9285 Mc/s. The measurements were carried out on a direct-amplification radiospectrometer with automatic recording of the absorption lines on a recorder.

Fig. 1 shows a diagram of the low-temperature part of the apparatus. The rectangular resonator 3, excited in the H_{01} wave, is placed in a hermetically sealed helium Dewar 2, which is installed in a nitrogen Dewar 1. The Teflon bulb containing the substance under study 4 is located at the maximum of the magnetic field strength of the high-frequency field. The inner cavity of the resonator is hermetically sealed off from the feeding waveguide line by mica 7. To reduce heat transfer, constantan transitions were used both in the waveguides and in the feeding fittings.

Fig. 3. Dependence of the height of the MnS absorption maxima on temperature

The entire system is placed between the poles of an electromagnet so that the constant magnetic field is perpendicular to the component of the magnetic field strength of the high-frequency field at the place where the sample is located.

Before the measurements were begun, the helium Dewar was evacuated and filled with the required amount of purified heat-exchange gas. After Dewar 1 had been filled with liquid nitrogen, heater 6, with adjustable power, was switched on; the power was set depending on the required temperature, measured by differential thermocouple 5. After the temperature of the sample had stabilized, measurements of the resonance absorption were carried out. During the experiment the level of liquid nitrogen in the Dewar was maintained within specified limits.

Fig. 2 presents resonance curves obtained at various temperatures. As is seen from the graph of the dependence of the height of the resonance-absorption maxima on temperature, the absorption first increases somewhat as the temperature is lowered, and then drops sharply as the transition point T_N is approached. The half-width of the absorption lines (Fig. 4) rapidly increases near T_N. Such a temperature dependence of the height of the resonance maxima can apparently be satisfactorily explained by the combined influence of magnetic susceptibility and short-range magnetic order, as was noted in Ref. (7).

Fig. 4. Half-width of the MnS resonance curves as a function of temperature

The temperature dependence of the resonance absorption obtained in the present work, like the analogous results of Ref. (5), does not agree with the results of Okamura et al. (4). At the same time, in the present work no noticeable residual resonance absorption below -155° was observed, of the kind noted in Ref. (5). It may evidently be considered that the residual resonance absorption is connected only with insufficient purity of the samples studied.

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Note: Figure translations are in progress. See original paper for figures.