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INVESTIGATION OF METAMAGNETIC TRANSITION IN $FeCl_2$ WITH THE AID OF POLARIZED NEUTRONS

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A metamagnetic transition may produce in $FeCl_2$ regions with nonuniform magnetization distributions; these regions can lead to a strong decrease of the magnetic hysteresis compared with that expected theoretically [1]. Such regions should apparently lead to depolarization of neutrons passing through the sample. A study of the depolarization can yield information both on the magnitude of the critical field H_c^0 and on the process of formation of the saturated phase in the metamagnetic transition.

To investigate the transition with the aid of polarized neutrons, we used a triaxial spectrometer, on the operating stage of which we mounted a helium cyrostat with which it was possible to obtain temperatures 1.3 - 4.2°K in the working volume.

The magnetic field was produced with superconducting solenoids.

Preliminary experiments performed on polycrystals [2] indicated that the metamagnetic transition causes strong depolarization of the neutrons passing

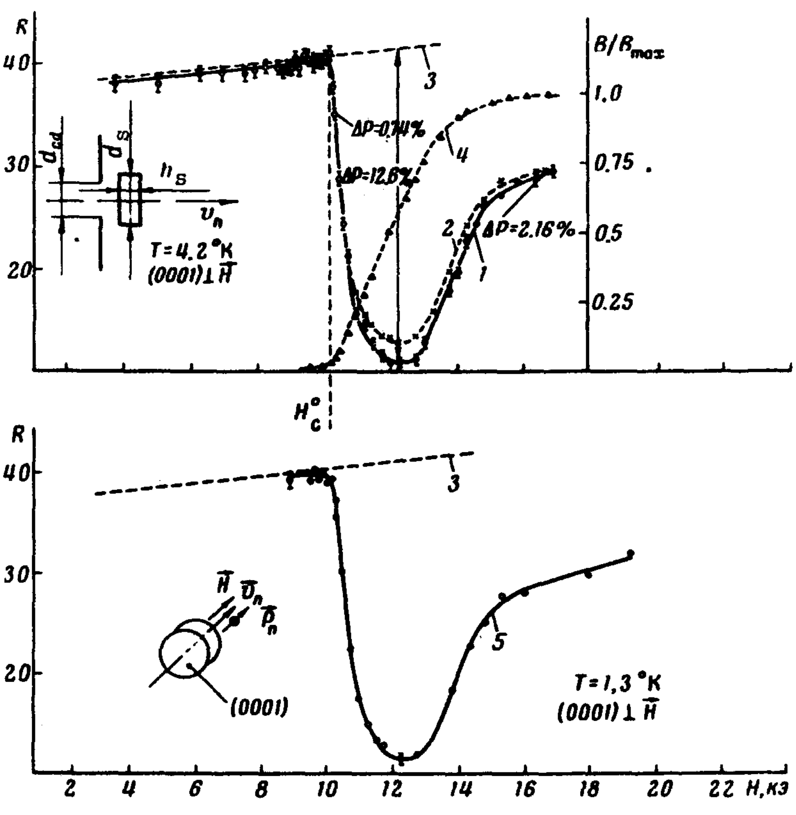

Fig. 1. Dependence of R on the magnetic field H at H ⊥ (0001) for $FeCl_2$. d_{cd} = 0.8 cm - diameter of cadmium diaphragm limiting the neutron beams, h_s = 0.63 cm - sample thickness, d_s = 1.1 cm - sample diameter, v - neutron velocity, P_n - neutron polarization, P - change of polarization.

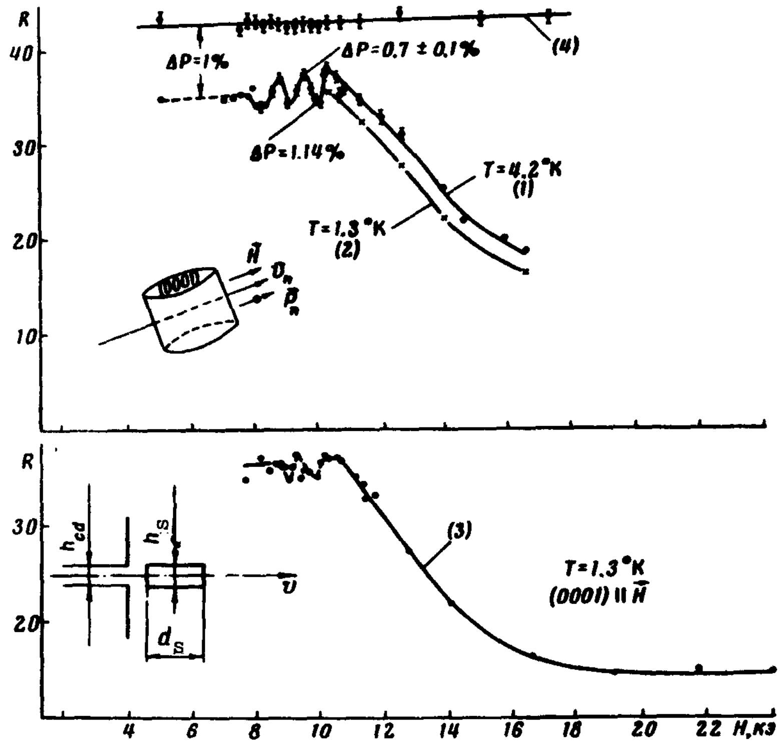

Fig. 2. Plot of R against the external magnetic field H at H ⊥ [0001] for $FeCl_2$, h_{cd} = 0.25 cm - width of cadmium slit in front of the sample, h_s = 0.3 cm, d_s = 1.1 cm.

through such a sample. The critical field obtained in these experiments is (10.5 ± 0.1) kOe.

Subsequent measurements were performed with single-crystal samples. Figure 1 shows the results of an investigation of the polarization ratio R of the neutrons passing through single-crystal $FeCl_2$, as a function of the field H. A decrease of R corresponds to a decrease of the neutron polarization. The experimental setup and the sample dimensions are indicated on Fig. 1. Curve 1 is a plot of R = f(H) when the external field increases, and curve 2 when the magnetic field decreases. R = f(H) for the empty solenoid is represented by the dashed line 3. Curve 4 describes our "magnetic" measurements of the sample magnetization and agree well in shape with the results of [1]. The results of these experiments are presented in relative units and have an illustrative character. The results of the measurement of R = f(H) at T = 1.3°K are shown in curve 5. This curve barely differs from curve 1. The experiments reveal a sharp growth of the depolarization at H = 10.3 kOe. The critical field H_c^0 of the metamagnetic transition, obtained in these experiments, equals (10.3 ± 0.1) kOe.

The course of the R = f(H) plot can be explained as follows: at the threshold field H_c^0 there are produced spontaneously small regions of the new phase, and the magnetization of the new phase may not have the same direction as the field or the neutron polarization. The appearance of such regions leads to depolarization of the neutrons. With further increase of the magnetic field, the volume of the regions increases, as does also the neutron depolarization. The growth of the regions of the new phase continues until they fill the entire volume of the sample. This instant corresponds to the minimum of R. The subsequent magnetization process consists of rotating the magnetic moments of different regions (domains) to align them in the direction of the external magnetic field. The presence of two stages in the sample-magnetization process

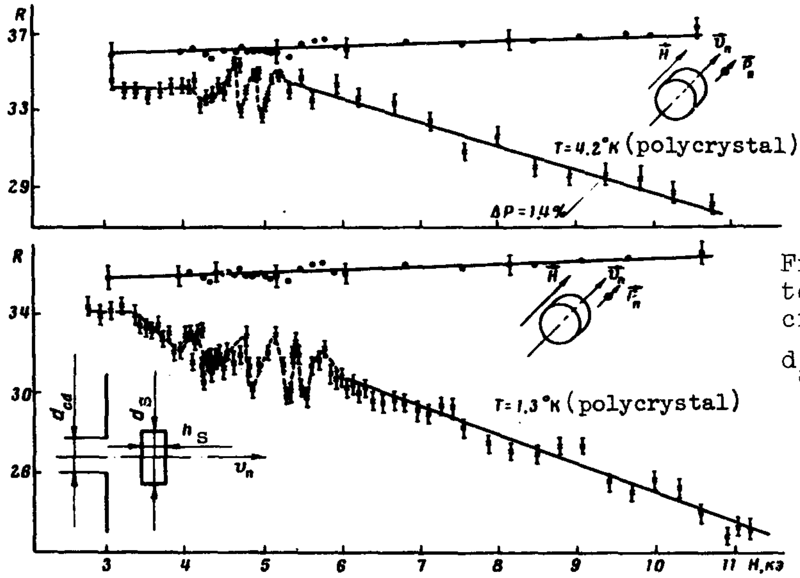

Fig. 3. Dependence of R on external magnetic field H for polycrystalline $MnCl_2$: d_{cd} = 1 cm, d_s = 1.1 cm, h_s = 0.7 cm.

possibly explains why the experimentally determined demagnetizing factor differs from that calculated from the geometric dimensions of the sample in [1]. The presence of an inhomogeneous distribution near the saturation state is apparently confirmed by observation of slight hysteresis in this range of fields. This hysteresis is due to the hysteresis of the domain structure.

Measurement of R = f(H) at $H < H_c^0$ points to the absence of some depolarization and to the presence of regions with inhomogeneous distribution of the magnetic moment. It is possible that such "centers" can be induced by the field near the metamagnetic transition and they play the role of nuclei of the new phase in the transition. To study the nature of such "centers," we investigated R = f(H) with H ⊥ [0001], i.e., with the $FeCl_2$ single crystal magnetized in a direction where no metamagnetic transition is observed [3]. The results of the investigation, the geometry of the experiment, and the sample dimensions are indicated in Fig. 2. Curve 4 corresponds to the polarization ratio of the empty solenoid. Curve 1 is a plot of R = f(H) (sample in neutron beam) at T = 4.2°K, and curves 2 and 3 were obtained at T = 1.3°K. It is seen from the results of this experiment that at a certain $H \geq H_c^0$ the depolarization increases, and becomes larger with decreasing temperature. In the region of 18 kOe, the depolarization reaches its maximum value and remains practically constant up to 24 kOe at T = 1.3°K. The sharp decreases is preceded by several successive minima in the value of R, which are clearly seen at T = 4.2°K. When the temperature is reduced to 1.3°K, they become less distinct. The possible cause of such a variation of R may be the periodic distribution of the magnetic moment inside the sample in a direction perpendicular to the field H, which can cause spatial spin resonance [4].

Curve 1 of Fig. 2 is very similar to the results of the investigation of polycrystalline $MnCl_2$. In Fig. 3, curves 1 and 3 are for the empty solenoid, and curves 2 and 4 for the solenoid with the $MnCl_2$ sample. The geometry of the experiment and the dimensions of the sample are indicated in the figure. Preliminary investigations of single-crystal gave a similar R = f(H) relation. The decrease of the polarization in fields exceeding the field of the spin-flop transition $H_{sf} \simeq 5$ kOe, can be attributed to the appearance of a weakly-ferromagnetic phase and to formation of domains [5]. Favoring this opinion is the presence of a transition at a temperature exceeding the Neel temperature

T_N = 1.96°K. A similar phenomenon was observed, for example, in FeF_3 [6]. Investigation of polycrystalline $CoSO_4$ indicate that the transition to weak ferromagnetism causes depolarization of neutrons passing through such a sample.

All the foregoing favors the assumption of a possible existence in $FeCl_2$ of a transition to weak ferromagnetism near H_c^0. Regions with such a magnetic moment can serve as nuclei of the saturated phase in the metamagnetic transition.

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EXCITATION OF MAGNETOSONIC RESONANCE IN THE TOKAMAK PLASMA

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Considerable progress has been attained by now in the heating and containment of plasma by current in Tokamak installations [1]. It is known at the same time that the efficiency of Joule heating of the plasma decreases with increasing electron temperature. It therefore becomes vital to solve the problem of plasma heating with the aid of alternating electromagnetic fields, especially via excitation of magnetosonic resonance, which ensures penetration of the field into the plasma and even enhancement of the field [2].

We investigated the excitation of magnetosonic resonance (MSR) in a toroidal plasma with current in the TM1-VCh installation, which comprises a Tokamak [3] with major torus radius R = 40 cm, diaphragm radius a = 8 cm, stabilizing field H_m = 20 kOe, and discharge current I_m = 10 kA. The hydrogen pressure in the chamber was $P = (4 - 8) \times 10^{-4}$ Torr. The electron temperature, estimated from the conductivity, was T_e = 70 eV, and the charged-particle density (determined with a microwave interferometer) was $\bar{n} \gtrsim 2 \times 10^{13}$ cm^{-3}. The magnetosonic oscillations at 21 MHz were excited with a narrow coupling loop surrounding the plasma column. The signal was registered with the aid of magnetic probes lying inside the liner in the shadow of the diaphragm. One pickup was placed at a distance 22 cm away from the central plane of the excitation loop, outside the section bounded by the diaphragm, and could measure the local intensity $\tilde{H}_z$ of the HF magnetic field, and another pickup surrounded the column and the distance between it and the region of the exciter was equal to half the perimeter of the torus. The main measurements were made under conditions when the absorbed HF power ($P_{act} \lesssim$ 20 kW) was of the same order as