in the basal plane. In crystals having weak ferromagnetism the spontaneous moment can either be directed along a twofold axis (Dzyaloshinskii's state II), or lie in the plane of symmetry (state III).

We have made measurements of the hexagonal anisotropy in monocrystals of $MnCO_3$ and $CoCO_3$ prepared by a hydrothermal method by N. Yu. Ikornikova in the Crystallography Institute of the U.S.S.R. Academy of Sciences. The crystals of $CoCO_3$ were rather perfect monocrystalline platelets, bound by low-index planes, ~ 0.3 mm thick and 0.8—1 mm in diameter. The $MnCO_3$ crystals were larger, but less perfect. In both cases the trigonal axis [111] was perpendicular to the planes of the platelets.

Circular disks were prepared from these crystals by means of a special tool on an ultrasonic drilling machine. The $CoCO_3$ sample had a diameter of 0.6 mm and a thickness of 0.35 mm. Its measured volume was 1.11×10^{-4} cm^3 and its weight 0.472 ± 0.01 mg, corresponding to a density $\rho = 4.25$ g/cm^3; this is in good agreement with the tabulated value $\rho = 4.13$ g/cm^3. The $MnCO_3$ crystal was found to be much softer, and the shape of the sample after machining was less perfect. Its diameter was 1.3 mm and thickness 0.35 mm.

The anisotropy measurements were carried out on a torsion balance with a quartz suspension 35 μ in diameter. The suspension constant D = 1.86 dyne-cm/rad; the balance constant D' = 1.24×10^{-3} dyne-cm/mm with a precision of reading ~ 0.1 mm.

The measurements were conducted at the temperatures of liquid helium, hydrogen, nitrogen, and at room temperature in a field of 5600 oe; this value is approximately twice as large as the saturating fields of these substances determined by Borovik-Romanov and Ozhogin.[2,3]

The $MnCO_3$ sample showed a weak hexagonal shape anisotropy at all temperatures and practically no crystallographic anisotropy below the Neél point (32.5° K[2]). Our preliminary measurements indicate that the anisotropy, if observed at all, is in every case, less than 1 erg/cm^3. This result is in contradiction to the data of Date,[4] who, using the results of ferromagnetic resonance measurements, obtained for the anisotropy field a value that is at least an order of magnitude greater than that which follows from our data.

Unlike the $MnCO_3$, the $CoCO_3$ sample showed a very strong hexagonal anisotropy. At 4.2° K we obtained a value $K_3 = 634$ erg/cm^3; $K_3 = 0$ at all other temperatures used, which lie above the Neél temperature (18.1° K[3]). Preliminary measurements indicate a very fast drop in K_3 with temperature.

Using the relation $H_c = 18K_3/I_s$ (where H_c is the critical field at which saturation associated with uniform rotation is attained and I_s is the spontaneous ferromagnetic moment per unit volume, equal to 50 cgs esu[3]), we obtain $H_c = 228$ oe.

This value as well as the much smaller one for $MnCO_3$ is an order of magnitude different from the actual saturation field, which in both cases amounts to 2—3 koe. This indicates the presence of some other magnetization processes.

The authors sincerely thank P. L. Kapitza for his interest in the work and A. S. Borovik-Romanov for valuable advice and helpful discussions.

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THE PHOTOMAGNETIC EFFECT IN A p-n *JUNCTION*

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Submitted to JETP editor September 25, 1961

J. Exptl. Theoret. Phys. (U.S.S.R.) **41**, 1692-1694 (November, 1961)

STUDIES of the photomagnetic effect in semiconductors have shown that illumination of the contacts (electrodes) influences the measured photomagnetic emf, especially at low temperatures. This behavior suggests that the photomagnetic effect may appear in the blocking layer formed at the boundary between a semiconductor and a metal. The present letter describes some experiments designed to check this suggestion.

1. A sample of germanium in the form of a rectangular 10 × 4 × 4 mm parallelepiped was

used. Metallic indium was fused onto one of the 4 × 4 mm ends of the sample, forming a diffused p-n junction. The opposite 4 × 4 end had an ohmic contact (tin). The photomagnetic potential difference between these two contacts was measured with the sample illuminated in a magnetic field normal to the length of the sample. The measured potential difference was the sum of the photomagnetic emf's of the homogeneous part of the sample and of the p-n junction. The two emf's can be separated because the photomagnetic emf in the homogeneous portion is proportional to the illuminated length of the sample, while the junction emf is independent of the illuminated length.

The illuminated length of the sample was varied by moving a rectangular metal screen placed directly in front of the sample. The screen could be moved along the length of the sample from the ohmic contact to the p-n junction. Initially the whole sample was screened. As the screen was moved, the ohmic contact, the homogeneous part of the sample, and the junction were uncovered in the order listed. An emf was recorded without any magnetic field; this was the usual photo-emf across the p-n junction. This emf was balanced out by means of a potentiometer before application of the magnetic field. The potential difference produced by the magnetic field was measured by a null method for two opposite directions of the field. From these two measurements, the odd and even photomagnetic emf's were deduced.

Figure 1 gives the dependence of the measured odd photomagnetic emf at 77° K as a function of the screen displacement x, which represents the length of the illuminated part of the sample. The curve of Fig. 1 shows that initially the photomagnetic emf is proportional to x. Near the position of the junction the emf increases abruptly by an amount U_1, which is obviously the photomagnetic emf of the junction.

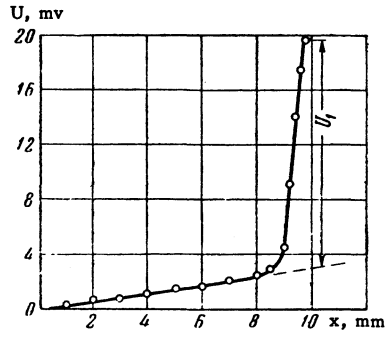

FIG. 1

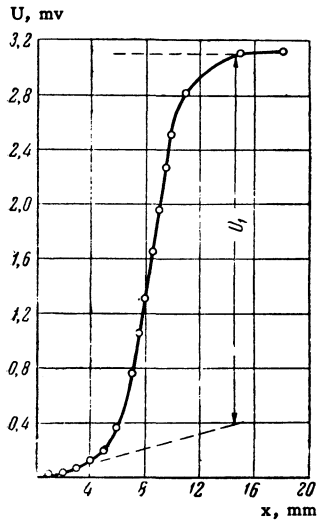

FIG. 2

2. To check whether the photomagnetic emf is not due to some edge effects, a p-n junction was produced in the middle of an 18 × 4 × 4 sample. Ohmic contacts were deposited on the two 4 × 4 mm ends of the sample and served as potential electrodes. Otherwise the procedure was the same as above.

Figure 2 gives the dependence of the odd photomagnetic emf as a function of the illuminated length of the sample at 300° K. The results of Fig. 2 confirm the existence of the photomagnetic effect across the p-n junction.

3. The same sample was used to measure the photomagnetic emf when direct current was passed through it. When the current was in the "blocking" (reverse) direction the photomagnetic emf was considerably greater than the emf in the absence of the current. In the "passing" (forward) direction the photomagnetic emf was not affected by the direct current (the potential drop across the sample accompanying passage of the current was balanced out).

4. The observed behavior could be considered to represent changes of the photo-emf in a magnetic field,[1] but supplementary experiments showed that the photomagnetic emf is not directly related to the photo-emf appearing across the p-n junction in the absence of a magnetic field.

Suitable treatment of the illuminated surface could alter the sign of the photomagnetic emf (this was observed also in homogeneous samples[2]) without affecting the sign of the primary photo-emf.

The photomagnetic emf was also measured on illumination through a narrow slit moved across the sample. Passage of the slit across the p-n junction produced a sharp maximum of photomagnetic emf.

Apart from the odd photomagnetic emf across the p-n junction, an even emf was also observed, but its nature was not clear.

A detailed description of studies of the photomagnetic effect in p-n junctions will be published later.

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SPIN-WAVE HEAT CAPACITY IN ANTIFERROMAGNETIC $MnCO_3$

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Submitted to JETP editor October 11, 1961

J. Exptl. Theoret. Phys. (U.S.S.R.) **41**, 1694-1696 (November, 1961)

INVESTIGATION of the temperature dependence of the heat capacity of antiferromagnetics gives the possibility of verifying the predictions of the theoretical law of dispersion of spin waves. However, up until the present time such investigations have not been carried out. In large part this is connected with the fact that in the usual antiferromagnets, because of the presence of a significant gap in the energy spectrum, the magnetic heat capacity should change exponentially, and in the low temperature region it is found to be small compared with the lattice heat capacity. One of the authors [1] has shown that in the case of the antiferromagnetic carbonates, in which the spins lie in the plane perpendicular to the three-fold axis, the spin-wave spectrum divides into two branches, one of which has practically no gaps. The result is that the magnetic heat capacity, beginning at very low temperatures, should vary according to a cubic law.

In the present work the temperature dependence of the heat capacity of $MnCO_3$ was studied from 1.6 to 80° K. The $MnCO_3$ compound in the form of tiny crystals was obtained by a hydrothermal method by N. Yu. Ikornikova of the Institute of Crystallography of the U.S.S.R. Academy of Sciences. [2] The measurements were carried out in a vacuum calorimeter similar to that used in [3,4] in the region 1.5—14° K and in an adiabatic calorimeter [5] from 14 to 80° K. The temperature was measured with a bronze thermometer below 4° K, a carbon thermometer between 4° and 14° K [6], and a platinum thermometer above 14° K. Figure 1 shows the general behavior of the heat capacity. The characteristic maximum corresponding to the transition of manganese carbonate from the antiferromagnetic to the paramagnetic state can be seen here. The heat capacity maximum is found at 29.5° K, which is 2.9° lower than T_N = 32.4° K, as determined from magnetic data. [1]

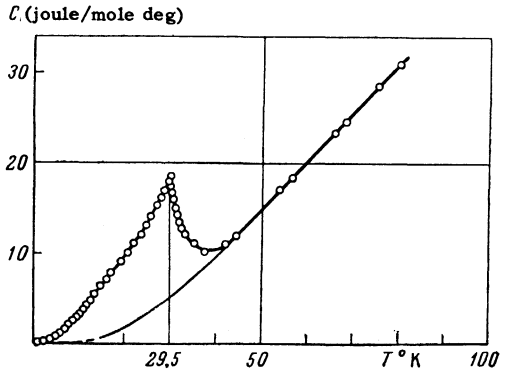

FIG. 1. Temperature dependence of the molar heat capacity of $MnCO_3$ (points and heavy curve) and $CaCO_3$ [7] (light curve) extrapolated to 0°K (dashes).

In order to separate out the magnetic heat capacity it was necessary to subtract the lattice and nuclear heat capacities from the data obtained. In order to estimate the specific heat of the lattice we made use of the results of Simon and Swain, [7] who investigated the temperature dependence of the heat capacity of diamagnetic $CaCO_3$, isomorphous

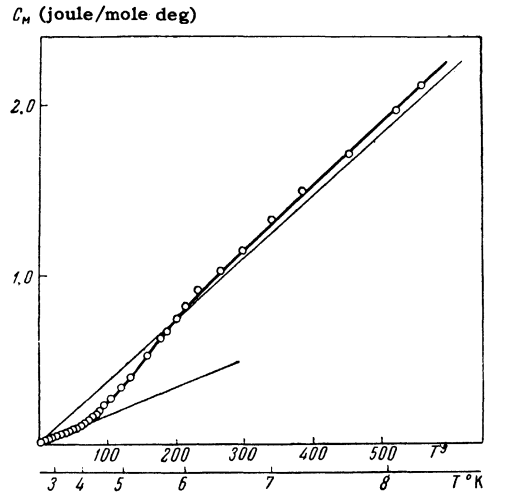

FIG. 2. Temperature dependence of the magnetic heat capacity of $MnCO_3$. (The light lines are according to the spin wave theory from the magnetic data. [1])