Letters to the Editor

PHOTOMAGNETIC EFFECTS IN GERMANIUM IN STRONG MAGNETIC FIELDS

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Submitted to JETP editor July 26, 1963

J. Exptl. Theoret. Phys. (U.S.S.R.) 45, 1678-1680 (November, 1963)

PHOTOMAGNETIC effects in germanium have been investigated in weak and moderately strong fields—up to 20,000 Oe. It was found that in such fields at relatively low temperatures (77°K) the even anisotropic photomagnetic emf U_{an} depends anomalously on the angle θ between the direction of the magnetic field and the normal to the illuminated surface of the germanium sample. [1] Under these conditions the dependence of the odd photomagnetic emf on the magnetic field deviates strongly from linearity.

The anomalous dependence $U_{an}(\theta)$ follows immediately from the unpublished work of Yu. M. Kagan and V. N. Sobakin, dealing with the transport theory of the anisotropy of the photomagnetic effects. This theory yields, in particular, the nontrivial conclusion that in strong fields (in the limit when $H \to \infty$) the value of the even photomagnetic emf becomes zero when $\theta = \pi/2$ (when the surface of the sample is parallel to the magnetic field direction). As regards the odd photomagnetic emf, the theoretical treatments (cf. [2,3]) lead to the conclusion that it should pass through a maximum at certain values of the magnetic field.

To check these theoretical conclusions, a study was made of the photomagnetic effects in strong pulsed magnetic fields (up to 150,000 Oe). The difficulties usually encountered in such studies (large stray induced emf's, which when compensated before illumination reappear during illumination, etc.) were overcome by the use of a solenoid with a large internal diameter (86 mm) and length 120 mm, in which the field pulse duration was 3 msec.[1)]

The test samples of n-type germanium, having an electrical resistivity $\rho = 40\ \Omega$-cm and diffusion length $L = 2.5$ mm, and of p-type germanium, having $\rho = 2.7\ \Omega$-cm and $L = 1.8$ mm, were cut in the form of rectangular slabs of $30 \times 5 \times 0.5$ mm dimensions. In the study of the odd photomagnetic effect, the samples were cut from an ingot in arbitrary fashion since we were not interested in the anisotropy of this effect. However, the samples intended for the study of the even anisotropic effect were cut in such a way that the even photomagnetic emf was a maximum along a direction perpendicular to the magnetic field and light beam. [4]

Both the open-circuit voltage (U) and the short-circuit current (J) were measured. Measurements were carried out with an oscillograph of OK-24 type. The samples were illuminated with focused light from an incandescent lamp.

Figure 1 gives typical curves of the dependence of the odd photomagnetic emf on the magnetic field intensity for n-type germanium at temperatures of 300 and 77°K (curves 1 and 2, respectively). Similar curves were obtained for p-type germanium. Thus, the photomagnetic emf, in agreement with the theory, passes through a maximum at a certain value of the magnetic field intensity which, other conditions being equal, depends on the state of the illuminated surface. On increase of the surface recombination velocity the maximum of the curve (Fig. 1) shifts, in accordance with the theory, toward weaker magnetic fields.

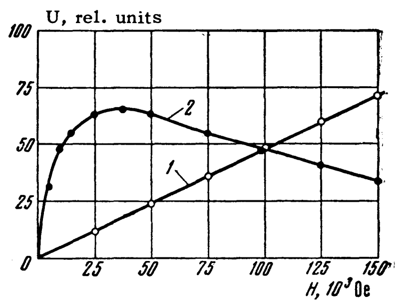

FIG. 1

Figure 2 gives curves of the dependence of the even anisotropic photomagnetic emf on the angle θ, obtained in a magnetic field of 150,000 Oe at temperatures of 300 and 77°K (curves 2 and 3, respectively). As expected, the anomalous dependence of the effect on the angle θ, similar to that found by Kikoin and Lazarev [1] at T = 77°K in a field of 20,000 Oe, appeared even at room temperature when a magnetic field of 150,000 Oe was used (curve 2). In weak fields (30,000 Oe) at T = 300°K this dependence (curve 1) approaches the "normal" form ($U_{an} \sim \sin^2 \theta$). At T = 77°K and H = 150,000 Oe we obtained curve 3, which coincides with the theoretical curve (Yu. M. Kagan and V. N. Sobakin, private communication) for a field $H \to \infty$. In weaker fields (for example, 17,000 Oe) this curve assumes a form similar to that of curve 2 in Fig. 2.

From the data of Fig. 2 we may conclude that for the anomalous dependence $U_{an}(\theta)$ to appear

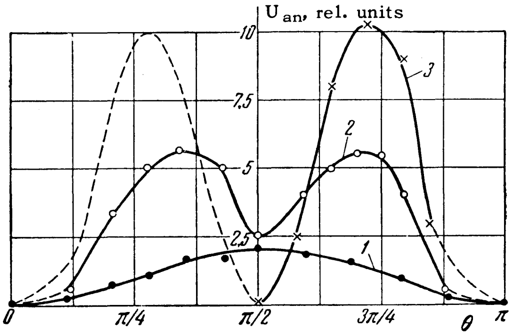

FIG. 2

it is only necessary that the factor $\mu H/c$ have a large value (μ is the Hall mobility of carriers, c is the velocity of light), irrespective of whether this value is obtained by increasing the magnetic field or increasing the mobility, as happens at low temperatures.

In conclusion the author takes this opportunity to thank Academician I. K. Kikoin for valuable discussions and interest in the present work, and L. M. Barkov and S. Kh. Khakimov for cooperation in the experiments.

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1)This solenoid was kindly made available by Prof. I. I. Gurevich, L. M. Barkov and S. Kh. Khakimov, and the present author is very grateful for this assistance.

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Translated by A. Tybulewicz

EFFICIENCY OF A SPARK CHAMBER FOR RECORDING CHARGED SHOWER PARTICLES

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Submitted to JETP editor September 5, 1963

J. Exptl. Theoret. Phys. (U.S.S.R.) **45**, 1680-1682 (November, 1963)

THE efficiency of a two-electrode spark chamber was determined in an arrangement consisting of two spark chambers of area 600×600 mm and interelectrode distances of 90 and 70 mm. The central electrode between the chambers consisted of 2-mm duraluminum sheet. Over the chambers was a 2-cm layer of lead in which the showers were produced by cosmic-ray electrons. A plastic scintillator with an FÉU-33 phototube was mounted under the chambers. When a shower of three or more particles passed through the scintillator, a pulse (100 kV) was applied to the chambers with a delay of 0.3 μsec. The chambers were filled with pure neon to a pressure of 765 mm Hg. The design of the spark chambers was similar to that of a chamber described earlier.[1] One of the electron showers recorded in the spark chambers is shown in Fig. 1.

We investigated the chamber efficiency q for recording a shower and the efficiency Q for recording individual particles in a shower. The quantity q was defined as the ratio of the number of showers recorded simultaneously in both chambers to the number of showers recorded in one chamber.

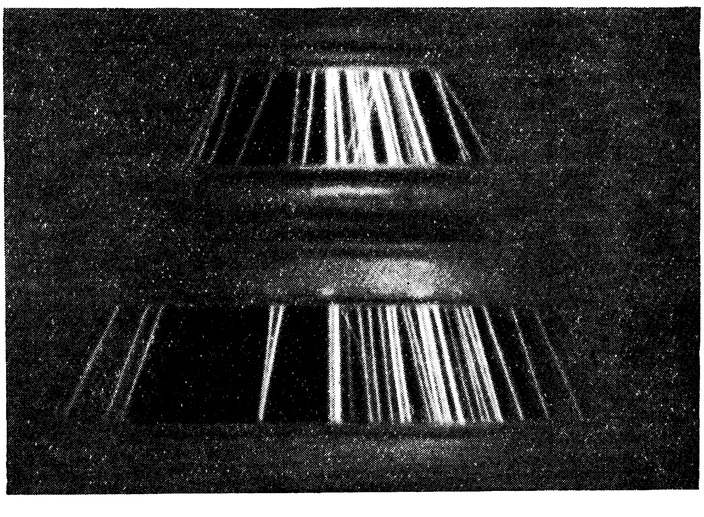

FIG. 1. Electron shower recorded in the spark chambers.