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ANISOTROPY OF THE EVEN PHOTOMAGNETIC EFFECT IN n-TYPE GERMANIUM AT LOW TEMPERATURES

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THE anisotropy of the even photomagnetic emf observed in germanium[1] is at room temperatures satisfactorily described by the phenomenological equations of Kagan and Smorodinskiĭ[2] right up to magnetic fields of 20,000 oe.

A study of the temperature dependence of the even photomagnetic effect showed that at low temperatures its anisotropy becomes anomalous. The investigation was performed on single crystal specimens of n-type germanium.

The orientation of the crystal axes and the direction in which the even photomagnetic emf was measured were chosen in such a way that only the anisotropic component was measured.[3] In order to do this the specimen which was cut in the form of a circular disc was mounted such that the [111] axis coincided with the normal n to the illuminated surface. If we take the direction of the magnetic field H to be along the x axis, and the direction of the light ray along the y axis, we measured the even photomagnetic emf in the z direction. The odd photomagnetic emf which occurs along the same direction was eliminated by measuring for two opposite directions of the magnetic field. Under those conditions the expression for the even photomagnetic emf E_q is of the form (see also reference 3)

$$E_q = \frac{1}{3\sqrt{2}} L H^2 \sin^2\theta \cos 3\varphi, \qquad (1)$$

if we assume that the above mentioned phenomenological equations can be applied; in Eq. (1) φ is the angle over which the specimen is turned around the normal **n**, θ the angle between the normal **n** and z (the direction of the magnetic field), and L a material constant.

The specimen studied could be rotated both in its own plane around the normal **n** (to change the angle φ) and also around the z axis (to change the angle θ).

The dependence of the even photomagnetic emf on the angle φ (which at the same time determines the anisotropy) which was obtained at liquid nitrogen temperatures agreed completely with Eq. (1), as it does at room temperatures. As far as the dependence of this emf on the angle θ is concerned, at a temperature of 78°K it is essentially different from that at room temperature ($\sin^2\theta$). The dependence is depicted in Fig. 1 where along the ordinate axis the extremum values of the even photomagnetic emf are given which correspond to $\varphi = \pi/3, 2\pi/3, \ldots.$ The different

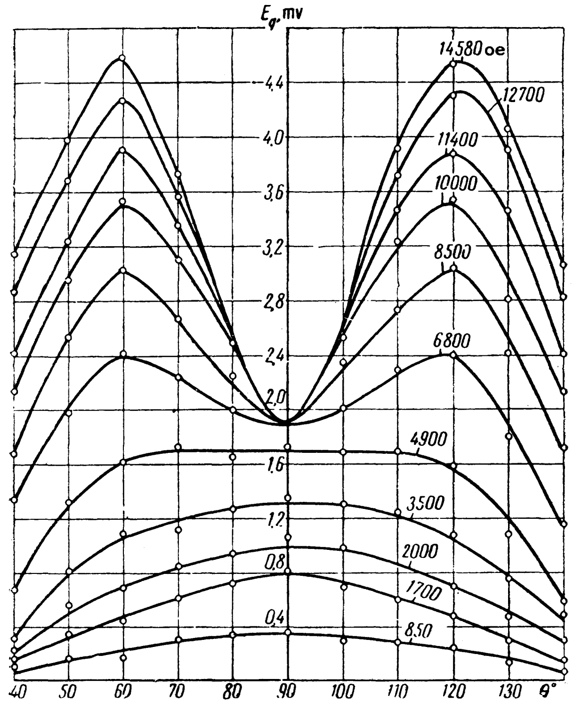

FIG. 1

curves correspond to the different values of the magnetic field given in the figure. While for small values of the field the angular dependence $E_q(\theta)$ approximately satisfies Eq. (1), at large values of the field ($H > 6000$ oe) it behaves anomalously. The value of the emf goes through a minimum at $\theta = \pi/2$, shows a maximum at $\theta = 54°$ and $126°$ and decreases to zero at $\theta = 0°$ and $180°$.

It is essential to note that the dependence of the even photomagnetic emf on the magnetic field is different for different angles θ, as can be seen from Fig. 2. Along the ordinate axis we have again given the extremum values of the even photomagnetic emf. For $\theta = \pi/2$ (the plane of the specimen is then parallel to the magnetic field) the even photomagnetic emf reaches saturation in relatively small fields, $H = 6000$ oe. At $\theta = 80°$ the value of the field for which saturation is reached is equal to 10,000 oe. For larger angles θ saturation does apparently not set in until fields which are larger than those attained in our experimental conditions are reached.

Qualitatively similar curves have been obtained for the emf produced when illumination is replaced by an electrical current from an external emf source flowing through the specimen, in the direction of the incident light.

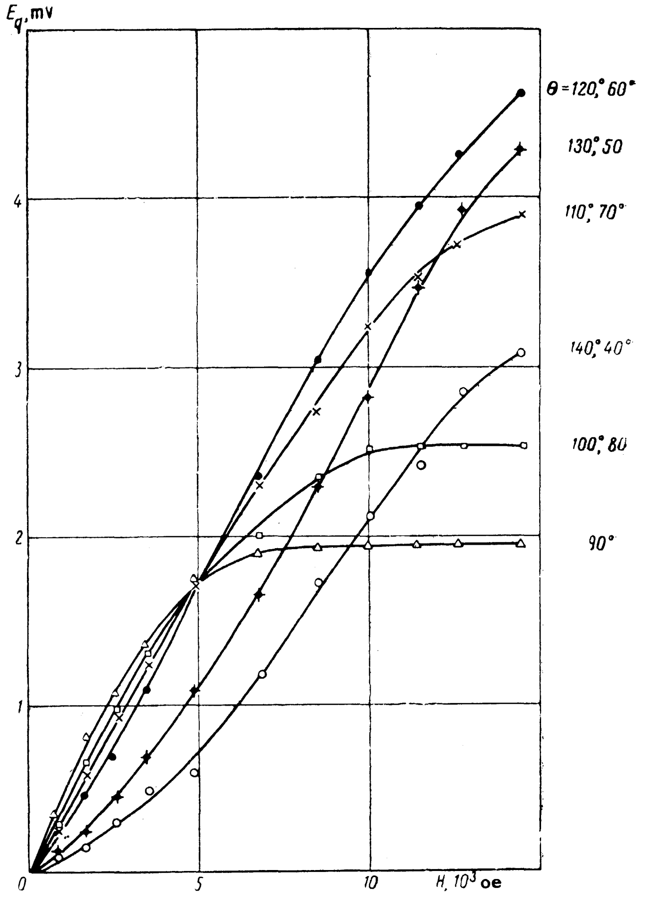

FIG. 2

At the moment we cannot suggest a satisfactory explanation of the observed anomalies. It is possible that they are connected with the presence of many carrier effective masses[4] each of which "shows up" at an appropriate angle θ.

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CONCERNING THE RADIATION OF A NUCLEUS IN THE PRESENCE OF UNEXCITED NUCLEI OF THE SAME TYPE

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If the emission of a γ quantum by an excited nucleus takes place in the presence of one or several nuclei of the same type, it becomes possible for the γ quantum to "wander" inside such a system. As will be shown below, in many cases this may lead to a change in the observed frequency and to a damping of the radiation (see also reference 1). It is assumed that the nuclei can be regarded as isotropic classical oscillators.

1. We consider the question of the radiation of a nucleus which is a component of a symmetric diatomic molecule, the axis a of which is fixed in space ($a \gg \lambda$, where λ is the radiated wavelength). The radiation field of such a molecule at a point far from the molecule and at an angle ϑ to its axis (which is assumed directed from the oscillator with dipole moment P_0 to the oscillator with dipole moment P_1), can be determined