[1] B.N. Taylor, W.H. Parker, and D.N. Langenberg, Revs. Mod. Phys. 41, 375 (1969).
[2] A. Pais and O. Piccioni, Phys. Rev. 100, 1487 (1955).

# GAUSS-AMPERE CHARACTERISTICS IN p-Ge IN STRONG ELECTRIC FIELDS

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There has been much recent interest in different effects connected with inelastic scattering of carriers in semiconductors [1 - 5]. It was shown in particular in [1 - 2] that in the case of inelastic scattering by optical phonons $\omega_0$ at temperatures $T \ll \omega_0$ and at a magnetic field $H_c$, in a definite interval of electric fields $E^- \ll E \ll E^+$, singularities appear in the gauss-ampere characteristics, namely a sharp decrease of the dissipative current and a maximum of the Hall current.

The experiments described in the present communication were performed for the purpose of observing the indicated effect.

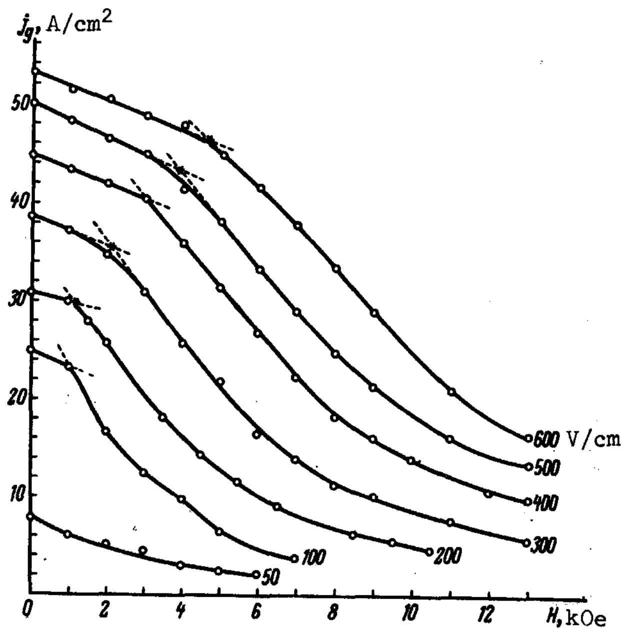


Fig. 1. Density of dissipative current vs. magnetic field.

The measurements were performed at 20°K on a p-Ge sample with resistivity 48 ohm-cm (carrier density $N_a - N_d = 3 \times 10^{13}$), in the form of a rectangular plate measuring 9 × 1.8 × 0.5 mm.

To eliminate the Hall potential [6], an alloy of tin with indium (80% Sn + 20% In) was melted into the long side faces of the sample by diffusion, and current electrodes were attached to this alloy. The pulsed electric field was always perpendicular to the magnetic field, which ranged from zero to 13 kOe. The maximum electric field intensity was ∿800 V/cm.

Figure 1 shows the gauss-ampere characteristics obtained at different values of the electric field. It is seen from the figure that in the region of electric fields from zero to 50 V/cm there are no noticeable singularities in the plot of the dissipative current against the magnetic field, and the current varies monotonically as the result of the magnetoresistance. In stronger electric fields it is possible to observe on the plot sections that have different slopes, and the point of inflection moves towards larger values of the magnetic field with increasing applied electric field. The dependence of E on the values of $H_c$ corresponding to these inflection points is a straight line (Fig. 2).

In analogous experiments performed for the case of open Hall contacts, no characteristic singularities were observed in the gauss-ampere curves.

Let us analyze the results from the point of view of the theory developed in [1, 2]. According to [1], the limiting values of the electric fields $E^-$ and $E^+$ are determined from the condition $eE^{\pm}\tau^{\pm} = P_0$, where $\tau^+$ is the time of spontaneous emission of the optical phonons, and $\tau^-$ is the time of elastic relaxation, amount to 40 and 3000 V/cm for p-Ge with carrier density $10^{13}$ $cm^{-3}$ at hydrogen temperature. The electric fields at which the characteristic singularities on the gauss-ampere characteristics were observed fall in the field interval predicted by the theory. The theory agrees also with the observed dependence of E on $H_c$, at which the dissipative current should disappear, and the slope of the $E = \phi(H)$ plot coincides with the theoretical value $E/H_c = P_0/2cm$ within 20%. The indicated agreement with theory gives grounds for assuming that the observed singularities on the $j = f(H, E)$ curve are connected with the changes of the distribution function of the carriers [1] when critical magnetic fields are applied to the sample. The reason why only a kink is observed on the $j = \phi(H, E)$ curve at the points corresponding to the critical magnetic field, instead of a steep decrease, still remains unclear.

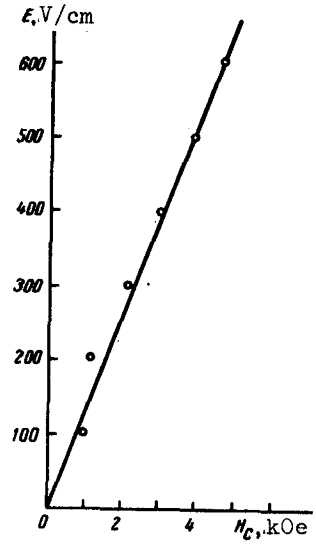

Fig. 2. Connection between the electric and magnetic fields corresponding to the inflection points on the $j = \phi(H, E)$ curves.

It is possible that one of the reasons for such a behavior of the gauss-ampere characteristics is the large initial momentum spread $\Delta P$, which can be possessed by the carriers prior to the application of the electric field, as a result of which they reach the energies of the optical phonons at different values of E, and also the fact that the frequency of the optical phonon has likewise a definite spread. Naturally, these causes cannot explain fully the fact that the dissipative current does not vanish.

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[1] I.I. Vosilyus and I.B. Levinson, Zh. Eksp. Teor. Fiz. 50, 1660 (1966) [Sov. Phys.-JETP 23, 1104 (1966)].

[2] I.I. Vosilyus and I.B. Levinson, ibid. 52, 1013 (1967) [25, 672 (1967)].

[3] F.G. Bass, Yu.G. Gurevich, I.B. Levinson, and Yu.A. Matulis, ibid. 55, 999 (1968) [28, 518 (1969)].

[4] F.G. Bass, I.B. Levinson, and O.N. Chavchinidze, ibid. 52, 1263 (1967) [25, 839 (1967)].

[5] I.I. Vosilyus, Litovskii fizich. sbornik (Lithuanian Physics Collection), No. 1-2, 1968.

[6] V.N. Dobrovol'skii and Yu.I. Grishchenko, Fiz. Tverd. Tela 4, 2760 (1962) [Sov. Phys.-Solid State 4, 2025 (1963)].


## DIRECT OBSERVATION OF ANOMALOUS TRANSMISSION OF RESONANT $\gamma$ RAYS OF $Fe^{57}$ BY SINGLE CRYSTAL Fe + 3% Si


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