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EFFECT OF SPIN ON THE LONGITUDINAL MAGNETORESISTANCE IN INDIUM ANTIMONIDE AT 4.2°K

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The effect of spin on the longitudinal magnetoresistance for a degenerate electron gas with the carriers scattered by ionized impurities was considered theoretically by A. L. Efros [1]. He has shown that whenever

$$\zeta = h\Omega(N + \frac{1}{2}) + S\mu H \qquad (N = 1, 2, \ldots) \qquad (1)$$

the component σ_{zz} of the conductivity tensor has sharp minima, and the experimentally measured quantity $\rho_{zz} = 1/\sigma_{zz}$ has sharp maxima. Here μ is the spin moment of the electron, N the principal quantum number, ζ the chemical potential, $\Omega = eH/m^*c$ the Larmor frequency, and $S = \pm 1$. Thus, as in the transverse magnetoresistance, the spin should lead to doubling of the maxima. If the spin does not flip during the scattering process then, according to [1], no zeroth maximum 0^+ should be observed. The conditions for experimental observation of the influence of spin splitting of the Landau levels on the quantum oscillations of the resistance in a longitudinal magnetic field are the same as in a transverse field. We have observed earlier [2] the influence of spin splitting of the Landau levels on the transverse magnetoresistance in InSb.

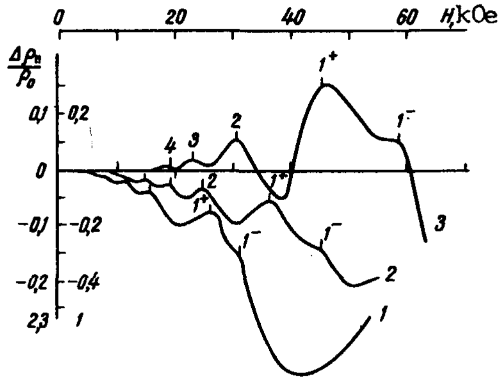

Fig. 1. Plot of $\Delta\rho_{\parallel}/\rho_0(H)$ for samples 1 - 3.

In this paper we present experimental evidence of the influence of the spin on the quantum oscillations of the longitudinal magnetoresistance in indium-antimonide samples at 4.2°K. The results of measurements of $\Delta\rho_{\parallel}/\rho_0(H)$ for samples 1 - 3 are shown in Fig. 1 (1 - $n = 4 \times 10^{16}$ cm^{-3}, 2 - $n = 7.35 \times 10^{16}$ cm^{-3}, 3 - 9.6×10^{16} cm^{-3}). To identify the maxima, the measurements were made up to magnetic field values for which the oscillations vanished and $\Delta\rho_{\parallel}/\rho_0(H)$ varied monotonically. Figure 2 shows the $\Delta\rho_{\parallel}/\rho_0(H)$ curve for sample No. 3. The same figure shows for comparison the $\Delta\rho_{\perp}/\rho_0(H)$ curve for the same sample. The bars in Figs. 1 and 2 mark the positions of the experimentally observed maxima, while the indices 0^+, 1^-, 1^+, 2, etc. indicate the numbers of the maxima.

It is seen from Figs. 1 and 2 that the first maxima split into 1^+ and 1^-. Comparison with the transverse oscillations in the same samples show that the positions of the longitudinal and transverse maxima for N = 1, 2, etc. coincide quite satisfactorily.

There are no zeroth maxima in the longitudinal case. The absence of 0^+ maxima in $\Delta\rho_{\parallel}/\rho_0(H)$ offers evidence that under the conditions of the present experiment the probability of scattering with spin flip in indium-antimonide is low.

It is of interest to note that in indium arsenide we observed no 0^+ maxima in the longitudinal magnetoresistance. It is evident that there is likewise no spin flip upon scattering in degenerate samples of that substance at low temperatures.

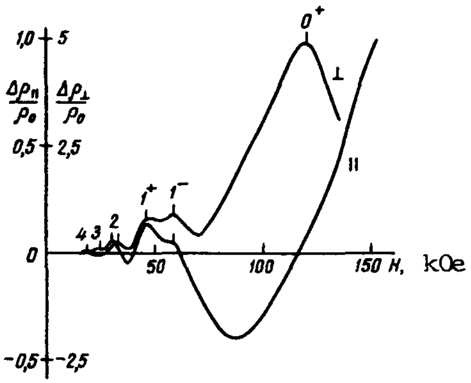

Fig. 2. Curves of the transverse (⊥) and longitudinal (∥) magnetoresistance of sample No. 3.

The positions of the maxima 1^- and 1^+ of the investigated samples can be calculated from the theoretical formulas derived for $\Delta\rho/\rho_0$ by L. E. Gurevich and A. L. Efros [3]. It is necessary in this case to specify the g-factor and the mass of the electron in the crystal. We made no such calculation. The effective mass of the electron (m^*) for different magnetic fields was taken from [5], and the g-factor was determined from the Roth formula [4].

Satisfactory agreement between the calculated and experimental maxima 1^+ and 1^- in samples 1 - 3 is observed when $m^*/m_{sp} = 0.34$ ($m_{sp} = 2m_0/g$ is the spin mass of the electron). Maxima 2 and 3, calculated from the theoretical formulas [6], coincide with the experimental values within the limits of accuracy.

The experimental results presented here thus confirm the theory developed in [1] for the longitudinal magnetoresistance.

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