[6] A. Finzi, Preprint, 1964.

[7] L. Hultén and M. Sugawara, Handb. Phys. **39**, 1 (1957).

[8] Bardeen, Cooper, and Schrieffer, Phys. Rev. **108**, 1175 (1957).

[9] Bohr, Mottelson, and Pines, Phys. Rev. **110**, 936 (1958).

[10] V. G. Solov'ev, Dissertation, Joint Inst. Nucl. Res. 1961: Izv. AN SSSR, Ser. fiz., **25**, 1198 (1961), Columbia Tech. Transl., p. 1207.

[11] R. P. Feynman, Prog. in Low Temperature Physics, North-Holland, Amsterdam, 1955.

Translated by J. A. Leggett
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NEW DATA ON THE MAGNETOPHONON OSCILLATION OF THE LONGITUDINAL MAGNETORESISTANCE OF n-TYPE InSb

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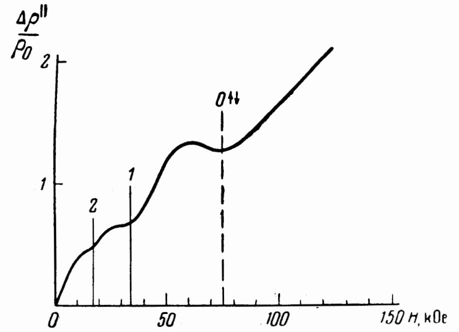
PARFEN'EV, Shalyt, and Muzhdaba[1] have shown that the oscillatory nature of the transverse and longitudinal magnetoresistance curves for nondegenerate samples of n-type InSb may be explained by the phenomenon of magnetophonon resonance predicted theoretically by V. L. Gurevich and Yu. A. Firsov.[2]



Curve showing the dependence of the longitudinal magnetoresistance of n-type InSb on the magnetic field intensity at T = 90 °K. The electron density was $n = 6 \times 10^{13}$ cm^{-3}, and the mobility was $u = 6 \times 10^5$ cm$^2 \cdot$ V$^{-1} \cdot$ sec^{-1}. The vertical lines identified by indices (M = 1, 2) indicate the resonance values of the field.

Further experimental investigation of this phenomenon in pulsed magnetic fields has made it possible to establish that the longitudinal magnetoresistance curve of n-type InSb has continued to oscillate in stronger fields beyond the upper limit of the interval established earlier, which extended only to 35 kOe (cf. the figure). It has been shown in [1] that the identification of the magnetic field values corresponding to the magnetophonon resonance condition ($\omega_0 = MeH/m^*c$, where M is an integer) is simple only for the transverse effect when, according to the theory, the resonance values of the field always correspond to the resistance maxima. It has been shown since [3] that the situation is much more complex for the longitudinal effect both in experiment (because a temperature shift of the phase of the oscillating curves was observed) and in theory (because of the need to allow for the fact that, characteristically, the various scattering mechanisms are competing against one another[4]). Therefore, reliable identification of the resonance values of the magnetic field for the longitudinal effect has to be made by comparing the experimental oscillatory curves of the longitudinal and transverse magnetoresistance, using the transverse effect maxima as the calibration points.

In the study up to 38 kOe, described in [1,3], both experimental curves were available and it was possible to establish that at sufficiently low temperatures the longitudinal effect curve had minima at the resonance values of the field. It was established, in particular, that the minimum at H ≈ 33 kOe should correspond to electron transitions between the two lowest unsplit Landau levels with quantum numbers zero and unity. Therefore, from the most general considerations, it follows that the oscillation of the magnetoresistance in stronger fields (H > 40 kOe), discovered in the present work, should be associated with the spin splitting of the Landau levels. However, a reliable determination of the resonance field values in this range of fields is difficult because the experimental curve of the transverse effect does not show oscillations in strong fields and the theory of transitions between split Landau levels with spin reversal under conditions of competition between various scattering mechanisms has not yet been developed. If we assume, on the basis of the results of the earlier work, that also in the region of strong fields (H > 40 kOe) at T = 90°K the resonance condition is satisfied by a minimum of the longitudinal magnetoresistance curve, the corresponding type of resonance condition may then be associated with two zero Landau sublevels, differing in the spin orientation. Since the experimental value of the field for the minimum considered here amounted to 75 kOe, the resonance condition ($\hbar\omega_0 = g\mu_B H$) gave a value $g = 56$ for the g-factor of electrons in InSb (for $n = 6 \times 10^{13}$ cm^{-3}, $T = 90°K$) which was in satisfactory agreement with other known data on this physical parameter[5] (ω_0 was assumed to be 3.7×10^{13} sec^{-1}[6]).

A more accurate quantitative treatment of the results, obtained with allowance for the energy band nonparabolicity, may be made only after considering the theoretical aspects of this problem.

According to Tsidil'kovskiĭ et al[7], a similar experimental result was obtained in their laboratory.

We are grateful to V. L. Gurevich and S. T. Pavlov for discussing the results obtained.

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[1] Parfen'ev, Shalyt, and Muzhdaba, JETP **47**, 444 (1964), Soviet Phys. JETP **20**, 294 (1965).

[2] V. L. Gurevich and Yu. A. Firsov, JETP **40**, 198 (1961), Soviet Phys. JETP **13**, 137 (1961).

[3] Firsov, Gurevich, Parfeniev, and Shalyt, Phys. Rev. Letters **12**, 660 (1964); Shalyt, Parfen'ev, and Aleksandrova, JETP **47**, 1683 (1964), this issue, p. 1131.

[4] V. L. Gurevich and Yu. A. Firsov, JETP **47**, 734 (1964), Soviet Phys. JETP **20**, 489 (1965).

[5] Lax, Mavroides, Zeiger, and Keyes, Phys. Rev. **122**, 31 (1961); G. Bemski, Phys. Rev. Letters **4**, 62 (1960).

[6] M. Hass and B. W. Henvis, J. Phys. Chem. Solids **23**, 1099 (1962).

[7] Tsidil'kovskiĭ, Aksel'rod, and Sokolov, FTT **7**, 316 (1965), Soviet Phys. Solid State (in press).

Translated by A. Tybulewicz
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