The currents of the Ca^{2+} and Sr^{2+} ions (curves 2) produced in the ion source increase rapidly at electron energy $\gtrsim$10 eV above their threshold. Such behavior was attributed in the case of calcium [3,4] to rapid auto-ionization processes occurring in the ion source at electron energy ~31 eV, corresponding to the binding energy of one of the internal $3p^6$ electrons of Ca. Similarly, the kink in curve 2 for Sr^{2+} can be attributed to fast auto-ionization processes in the ion source, since the kink occurs at an electron energy close to the binding energy of one of the internal $4p^6$ electrons of Sr, equal to ~27 eV according to [6]. The kinks on curves 3 coincide with these energies within the limits of the experimental error (±1 eV). But these curves characterize the doubly-charged Ca^{2+} and Sr^{2+} ions formed from the corresponding singly-charged ions in the chamber, under conditions when the contributions of the processes are small [2,3]. Consequently, at these electron energies there appears an admixture of strongly excited ions, which retain their excitation for $\gtrsim 10^{-5}$ sec and become doubly charged by auto-ionization. The form of curve s 3 is characteristic of the excitation of optically forbidden states.

It can be expected that other ions, isoelectronic to those investigated, can also have auto-ionization states with large lifetimes.

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NERNST EFFECT IN n-InSb IN A QUANTIZING MAGNETIC FIELD

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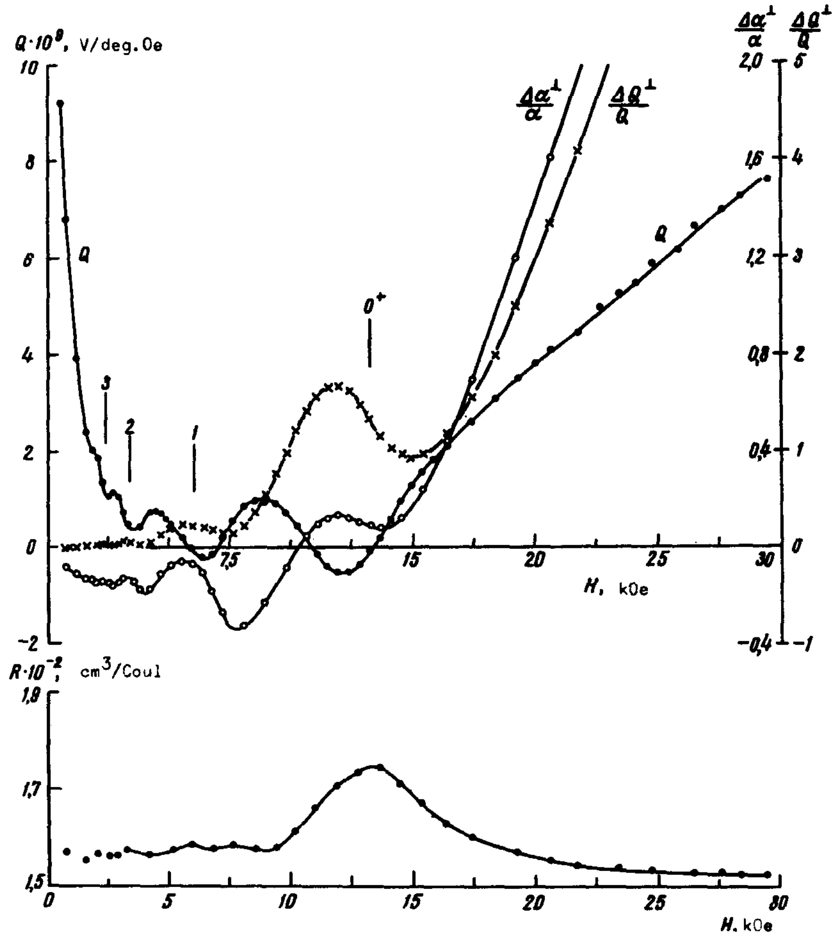
It was shown experimentally in [1] that quantization of the energy spectrum of the electrons of indium antimonide placed in a strong magnetic field becomes manifest at low temperatures in an oscillating field dependence of a number of kinetic coefficients. Although the main laws governing the oscillations of the magnetoresistance and the magnetothermal emf of n-InSb in transverse and longitudinal magnetic fields agree with the theory, the behavior of the Hall effect, the phase shift of the magnetothermal-emf curves, and a number of other details connected with spin splitting of the Landau levels, cannot be explained in the existing theory and call for its further development.

We report here briefly some experimental results of an investigation of the thermomagnetic Nernst effect [1)] in n-InSb. Our experimental conditions (temperature, carrier density, range of magnetic fields) not only enabled us to observe for the first time oscillations of the Nernst effect in a semiconductor, but also to follow continuously the sharp decrease of the Nernst coefficient in the classical region of strong fields ($uH/c \gg 1$), its transition in the region of quantum oscillations ($\xi \geq \hbar\Omega \gg kT$), and the subsequent transition to the region of the quantum limit ($\hbar\Omega \gg \xi$) (u = mobility, ξ = chemical potential, Ω = cyclotron frequency).



Experimental plots of the Nernst coefficient (Q), Hall coefficient (R), the magnetoresistance ($\Delta\rho^{\perp}/\rho_0$), and magnetothermal emf ($\Delta\alpha^{\perp}/\alpha_0$) vs. the intensity of the transverse magnetic field at $T \simeq 4°K$. The vertical bars marked with indices 3, 2, 1, and 0^+ indicate the theoretical values of the magnetic field at which the Fermi level is crossed in succession by the third, second, first, and zeroth Landau levels (for the latter - the upper spin sublevel 0^+).

To determine the phase relations, the Nernst-coefficient curve was compared with the plots of the magnetoresistance and the magnetothermal emf in a transverse field and with the plot of the Hall coefficient, obtained simultaneously in the investigation of single-crystal n-InSb measuring 1.25 x 3.8 x 70 mm, with electron density $n = 4 \times 10^{15}$ cm^{-3}, and mobility $u = 1.2 \times 10^5$ $cm^2/V\text{-sec}$ (at T = 4.2°K). The system of maxima on the plot of the Nernst coefficient Q at H_N = 4.5, 2.8, and 2.05 kOe form a periodic sequence in the reciprocal field: $\Delta(1/H) = 1.35 \times 10^{-4}$ Oe^{-1}, which agrees with the theoretical value of the period given by

$$\Delta(1/H) = (3.18 \times 10^6)n^{-2/3}\ Oe^{-1}$$

and which coincides with the periodicity of the magnetoresistance and magnetothermal-emf curves. The maximum of the Nernst coefficient at H = 9 kOe drops out of this periodicity, since it is apparently due to crossing of the Fermi level $\xi(H)$ by the spin sublevel of the zeroth Landau level: $\epsilon_{0+} = \hbar\Omega/2 + (|g|/2)\mu_B H$. 2) The comparison of the plotted curves shows that the oscillating Nernst-effect curve is shifted relative to the in-phase magnetoresistance and magnetothermal-emf curves in a transverse field ($\Delta\rho^{\perp}/\rho_0$ and $\Delta\alpha^{\perp}/\alpha_0$) by four periods, similar to the shift observed in [1] for the magnetothermal emf in a longitudinal field ($\Delta\alpha^{\parallel}/\alpha_0$). It must be noted that the arrangement of the maxima of the $\Delta\rho^{\perp}/\rho_0$ and $\Delta\alpha^{\perp}/\alpha_0$ curves on the magnetic-field scale agrees with the existing theory 1). The experimentally observed phase shift of the Q and $\Delta\alpha^{\parallel}/\alpha_0$ curves needs further theoretical analysis.

At the limit of the classical region of magnetic fields (H < 1.5 kOe), the Nernst coefficient decreases monotonically like $Q \sim H^{-1.3}$; 3) the increase of this coefficient in the region of the quantum limit (H > 17 kOe) is like $Q \sim H$.

The curve of the Hall coefficient shown in the figure exhibits slight oscillations at $H < H_{0+}$ and an oscillation with large amplitude, of unknown physical origin, on going into the region of the quantum limit.

It was established in [2,1] that the thermomagnetic phenomena in n-InSb can be strongly influenced at low temperatures by the dragging effect. In view of the fact that the Nernst effect under the conditions of the present experiment have not been adequately interpreted theoretically, a more detailed discussion of the experimental results can hardly be expected to be fruitful at present.

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1) In an unevenly heated conductor placed in a magnetic field, the potential difference in a direction perpendicular to the field and the temperature gradient are measured.

2) The curves of the longitudinal effects ($\Delta\rho^{\parallel}/\rho_0$ and $\Delta\alpha^{\parallel}/\alpha_0$) do not show the maximum at zero.

3) The signs of the Nernst effect and of the magnetothermal emf in this region correspond to the mechanism in which the carriers are scattered by ionized impurities.