Assume that the carrier diffusion coefficient D is much smaller than ℓ^2/τ (ℓ is the linear average dimension of the complex and τ is its average lifetime). Then, according to [4], the anisotropy of the electric conductivity of the nematic phase is determined to a considerable degree by the anisotropy of the electric conductivity of the complex. Recognizing that the nematic-ordering axis is a symmetry axis of infinite order, we obtain for the anisotropy of the electric conductivity of the nematic phase of OOBA

$$\Delta\sigma \sim -\Delta\sigma' \cos 2\alpha. \qquad (1)$$

Here $\Delta\sigma'$ is the anisotropy of a complex having molecular ordering of the smectic type A, for we know that $\Delta\sigma' < 0$. Hence, according to (1), the experimental behavior of $\Delta\sigma(T)$ can be attributed to a decrease of the angle α with decreasing temperature. The sign of the anisotropy reverses at $\alpha \sim \pi/4$.

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NEGATIVE CHARGE OF ELECTRON-HOLE DROPS IN GERMANIUM

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Drift of electron-hole drops was observed in germanium in a weak electric field. It is attributed to the negative charge possessed by the drops.

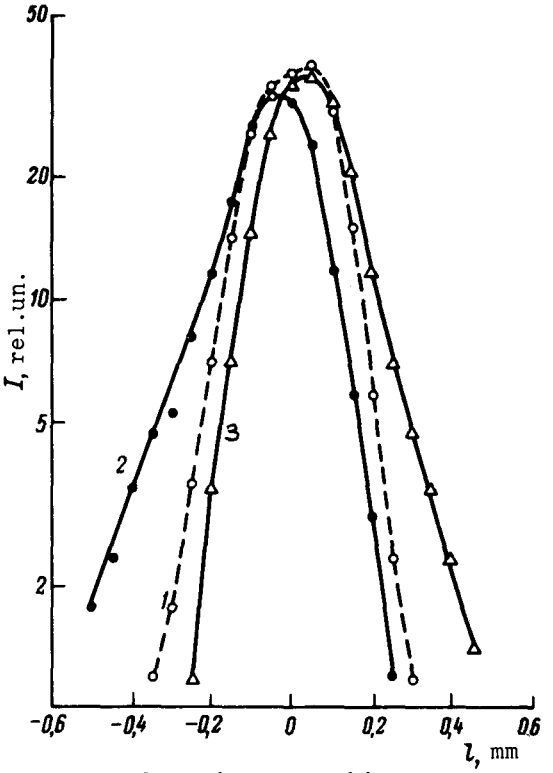
It was assumed in the analysis of the properties of the condensed phase of nonequilibrium carriers in semiconductors [1] that the drops are made up of electron-hole plasma, and that the number of electrons and holes in the drop as the same so that the drops are electrically neutral as units. This assumption, however, is not obvious, since the binding energies of the electrons and holes in the condensed phase may not be equal. An approximate calculation (private communication from T. M. Rice) shows that in the case of germanium the electron binding energy is approximately 0.5 meV higher than that of the holes. Therefore emission of holes from the drops will predominate until the negative charge of the drops becomes sufficient to equalize the rates of emission of the electrons and holes. If the crystal is continuously excited, there exist in the excitation region free electrons and holes that are not bound into excitons, and these screen the charge of the drop. According to the private communication from T. M. Rice, when the free-carrier density is approximately 4×10^{12} cm^{-3} (corresponding to an excitation rate 10^{20} - 10^{21} $cm^{-3}sec^{-1}$) the stationary charge of a drop of radius $R = 5\times10^{-4}$ cm should reach $\sim 500e$, where e is the electron charge.

We succeeded in determining the electric charge of electron-hole drops from the drift of the drops in weak electric fields. A sample of pure germanium measuring 11 × 5 × 0.5 mm was excited in quasistationary fashion with a helium-neon laser (wavelength 1.15 μ and power up to 10 mW) focused on the surface of the sample to produce a strip 0.1 mm wide. The magnified image of the surface of the sample, which was placed in superfluid liquid helium, was focused with a movable lens on the entrance slit of an MDR-2 spectrometer tuned to the recombination radiation of the condensed phase. By moving the lens in a direction perpendicular to the spectrometer slit we were able to determine the spatial distribution of the intensity of this radiation [2]. A dc voltage could ba applied to the ends of the sample through fused-in indium contacts. The intensity of the electron-hole drop radiation was registered at each position of the movable lens and at both polarities of the applied voltage, as well as in the absence of an electric field in the sample.

The figure shows the spatial distribution of the radiation of the electron-hole drops in the sample, in the absence of a field and at a field intensity E = 2.5 V/cm at both polarities. It is seen from the figure that in an electric field the radiation-intensity distribution is always shifted towards the anode relative to the center of the excitation region, regardless of

the polarity of the applied voltage. We propose that this displacement is due to the negative electric charge of the electron-hole drops. The drift displacement increased with increasing field intensity and reached a maximum at E ≈ 3 V/cm. Further increase of the field led to a strong increase of the current through the sample and to a decrease in the radiation intensity of the electron-hole drops [3].

It is also seen from the figure that at sufficiently large distances the intensity of the recombination radiation decreases approximately exponentially. The resultant characteristic length of the drop drift displacement is $L_d \approx 1.5\times10^{-2}$ cm. Using the relation $L_d = E\mu\tau_0$, and a lifetime $\tau_0 = 2\times10^{-5}$ sec for the condensed phase [1] we can, generally speaking, calculate the mobility μ of the electron-hole drops. In the excitation region, however, the concentration of the free carriers is much higher, and E is therefore much lower than in the remaining part of the sample. If the field E is assumed to be uniform, then we can estimate only the lower limit of the drop mobility, $\mu \geq 300\ cm^2V^{-1}sec^{-1}$. This value of the mobility seems reasonable. Indeed $\mu = Qe\tau_r/(m_e + m_h)N$, where Qe is the electric charge of the drop, m_e and m_h are the effective masses of the electrons and the holes, N is the number of electron-hole drops, and τ_r is the drop momentum relaxation time. Putting $R = 5\times10^{-4}$ cm, corresponding to $N = 10^8$ [1], $m_e + m_h = 5\times10^{-28}$ g, and $\tau_r = 10^{-7}$ [4, 5], we obtain $Qe = 10^2e$, which agrees in order of magnitude with the private communication from T. M. Rice.



Electron-hole drop recombination-radiation intensity I vs. distance ℓ to the center of the excitation region at 2°K: 1) electric field E = 0; 2) E = 2.5 V/cm, anode on the left; 3) E = 2.5 V/cm, anode on the right.

The presence of an electric charge in electron-hole drops in germanium explains certain experimental facts. Thus, when the level of the local excitation was increased, we observed an appreciable broadening of the region from which the electron-hole-drop radiation emanated. This broadening is natural for charged particles, owing to their electrostatic repulsion. The difference between the values of the drop diffusion coefficients determined at different excitation levels [2, 6] is apparently also connected with this broadening. The mutual electrostatic repulsion of the drops can explain also our unsuccessful attempts to obtain electron-hole drops of macroscopic volume ($\sim10^{-3}$ cm^3) by intense local excitation of germanium crystals. It is also possible that the interaction with the electrostatic potential of the charged drops leads to an increase of the anharmonicity of the plasma oscillations and explains the large width of the plasma-absorption and emission bands in the far infrared [7].

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