# "Flareup" of radiation of electron-hole drops under the influence of ultrasound

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The recombination radiation of electron-hole drops (EHD) was measured at temperatures 1.8–2.4 K in a Ge sample to which an ultrasound wave of intensity up to 15 W/cm$^2$ was introduced. "Flareup" of radiation of the EHD (by a factor 2–3) was observed.

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The interaction of electron-hole drops (EHD) with ultrasound was investigated experimentally and theoretically in Refs. 1–8. Absorption of ultrasound by the drops was observed in Refs. 1 and 3. The temperature dependence of the absorption coefficient had two sharp peaks near 2.4 and 3.2 K at an ultrasound frequency $\omega = 10^9$ sec$^{-1}$.

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We have previously[3] noted a small increase of the intensity of the EHD radiation with increasing ultrasound power. Ultrasound of frequency $10^9$ sec$^{-1}$ was excited in the sample with an electroacoustic converter (CdS). The nonequilibrium carriers were generated in the Ge with a gas laser of 1.52 $\mu$m wavelength and up to 12 mW power. The ultrasound absorption in the sample was measured by an echo-pulse method.

The results that follow were obtained at an ultrasound pulse duration $\tilde{\tau}_s = 0.6$ $\mu$sec, and the delay relative to the start of the optical-excitation pulse was $\tilde{\tau}_{del} = 150$ $\mu$sec. These values of $\tilde{\tau}_s$ and $\tilde{\tau}_{del}$ were chosen as a result of an analysis of the data obtained by measuring the "flareup" of EHD radiation as a function of $\tau_s$ and $\tau_{del}$. An interesting connection is observed between the magnitude of the effect $I/I_0$ and $\tau_s$ (Fig. 1). The intensity of the EHD radiation remained at the maximum attainable value (with $\tilde{\tau}_{del}$ and the optical-pumping power fixed) so long as $\tau_s$ did not exceed the value $2L/S = 4$ $\mu$sec, where $L$ is the length of the sample and $S = 5\times 10^5$ cm/sec is the speed of sound in Ge. In other words, the "flareup" effect was maximal until a standing wave was established over the entire length of the sample.

Under the conditions when EHD interact with ultrasound, we measured the spectral positions and shapes of the *LA*, *TA*, and *TO* replicas of the EHD emission lines. The measurements have shown that an ultrasound wave of intensity up to 15 W/cm$^2$ produces no noticeable changes in the EHD radiation characteristics listed above; thus, so important a parameter of the liquid phase as its density remained unchanged.

It was observed that the "flareup" of the EHD emission reached its largest value when nonequilibrium electrons and holes were generated near the sample boundary, where the ultrasound wave was reflected. With increasing distance of the region of excitation of the nonequilibrium carriers from the end face of the sample (Fig. 2) the effect decreased sharply and reached a minimum when the EHD were generated in the central part of the sample. No nonequilibrium carriers were excited near the opposite

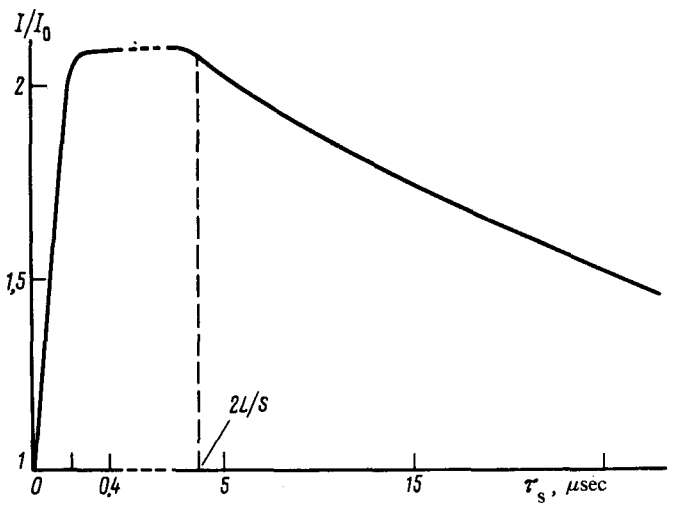


FIG. 1. "Flareup" of EHD emission vs duration of the sound pulse ($\omega = 10^9$ sec$^{-1}$, $T - 2.1$ K): $I$–intensity of EHD emission when an ultrasound power $\sim 10$ W/cm$^2$ is introduced; $I_0$–intensity of EHD emission in the absence of ultrasound.

end face of the sample, where the electroacoustic converter was located, to prevent light-sensitive effects from occurring in the CdS. When the ultrasound absorption by the EHD was measured simultaneously with the "flareup" effect it was observed that

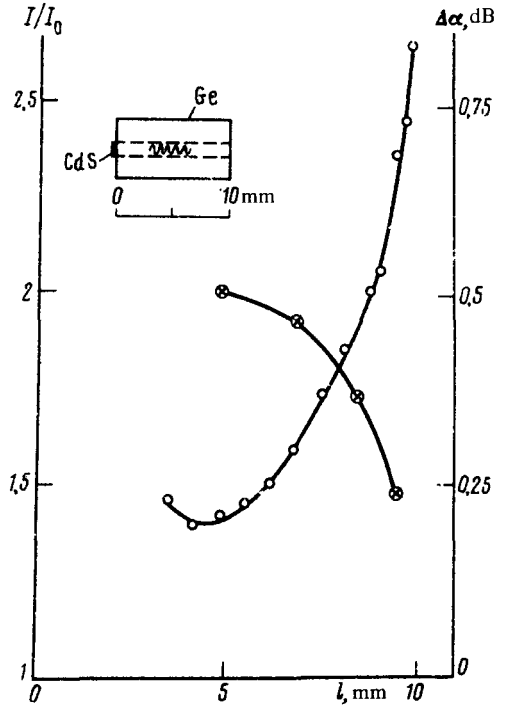


FIG. 2. "Flareup" of EHD emission vs the position of the region were nonequilibrium carriers in the sample. The right-hand ordinates are the values of the ultrasound absorption (the absorption was measured for an echo pulse with $N = 10$): ⊗ ultrasound absorption, ●–increment of EHD emission intensity following application of the ultrasound.

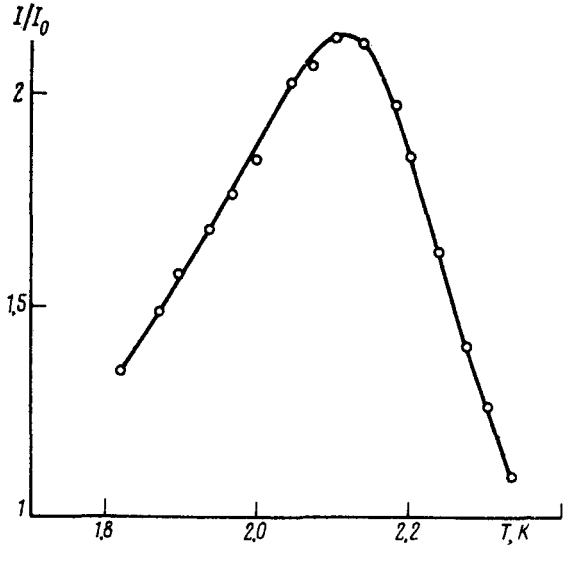


FIG. 3. Temperature dependence of the "flareup" of EHD emission.

the ultrasound absorption in the sample at $T < 2.4$ K decreased, when the region of generation of nonequilibrium carriers in the end face of the sample was approached.

We consider the most interesting result to be the temperature dependence of the "flareup" effect, as plotted in Fig. 3. Just as the temperature dependence of the ultrasound-absorption coefficient,[1,3] it has a sharp maximum as a function of temperature.

It is known that a traveling ultrasonic wave is capable of transporting both EHD and excitons over macroscopic distances in a crystal.[2-4,9] The increase of the EHD emission intensity under the influence of ultrasound as the carrier-generation region approaches the end faces of the sample, and the probable symmetry of this picture about the center of the sample, as well as the decrease of the magnitude of the "flareup" at $\tau_s > 2L/S$, all indicate that under the conditions of the experiment the free excitons and the EHD are dragged towards the end faces of the sample by the traveling ultrasonic wave. The "compression" of the exciton gas by the forward and reflected waves (which is most effective at the ends) has led to a shift of the equilibrium between the liquid and gas phases so as to increase the volume of the liquid. The EHD emission intensity increased as a result.

The fact that the "flareup" is temperature dependent is apparently due to the increase of the diffusion spreading of the exciton cloud and the decrease of its density[10] with decreasing temperature and with increasing friction between the excitons and the EHD drops against the crystal lattice with rising temperature.[4] Both factors hinder the "compression" of the two-phase system by the ultrasonic wave, and their joint action leads to the appearance of a maximum in the temperature dependence of the observed effect.

The decrease of the ultrasound absorption by the EHD near the sample boundary becomes understandable if it is recognized that in this case the EHD remain for a definite time interval in the region of a quasistanding wave. During this time, the ultrasound energy is not absorbed by the drops.

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