to the fact that the degree of polarization of the conduction electrons, per unit spin magnetic moment, is the same and the hyperfine field for the Sn impurity atoms is proportional, in first approximation, to this polarization.

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EFFECT OF OPTICAL ORIENTATION OF ELECTRON SPINS IN A GaAs CRYSTAL

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The electron spins in the conduction band of a crystal can be oriented with circularly polarized light. The occurrence of such an orientation in cubic crystals, for example, is connected with the difference between the probabilities of the $^4\Gamma_8 \to {}^2\Gamma_6$ interband transitions (Fig. 1) from the band of the heavy holes (I = 3/2) and the band of the light holes (I = 1/2). Thus, upon excitation with $\sigma^\pm$ light, the probabilities of the $\mp 3/2 \to \mp 1/2$ and $\mp 1/2 \to \pm 1/2$ transitions have a ratio 3:1 [1]. This leads to predominant orientation of the electron spins in a direction opposite to the angular momentum of the exciting light M. The maximum degree of orientation is $P_{max} = (n_- - n_+)/(n_- + n_+) = 50\%$, where n_+ and n_- are the numbers of excited electrons with spins directed parallel and antiparallel to M. The first to observe the occurrence of such an orientation were Lampel [2], by means of the signal of nuclear resonance in silicon, and Parsons [3], by means of the polarization of luminescence in GaSb.

Observation of circular polarization of luminescence in the solid solution $Ga_xAl_{1-x}As$ was recently reported [4]. Both in [3] and in [4], the excitation was with monochromatic light near the point k = 0. We present below the results of an investigation of the spin-orientation effect observed in a GaAs crystal for a wide range of exciting-light wavelengths. The measurements were performed on a p-type crystal with a hole density 2×10^{19} cm^{-3}. The degree of the spin orientation was measured by determining the degree of polarization ρ of the luminescence at λ = 8475 Å, in analogy with [3]. The effect was identified by the 180° reversal of the luminescence circular-polarization signal on going from σ^- polarized light to σ^+ and vice versa. In addition, depolarization of the luminescence under the influence of the magnetic field was observed, resulting from the precession of the electron spins up to the instant of emission (in analogy the well-known Hanle effect in gases).

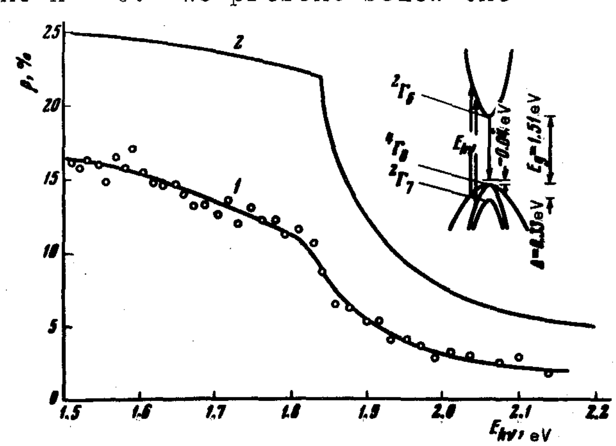

Fig. 1. Degree of polarization of luminescence in GaAs vs. energy of a photon of circularly-polarized exciting light: 1 - experimental curve; 2 - theoretical curve.

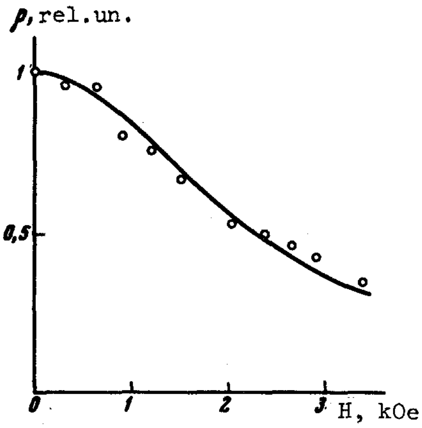

Fig. 2. Depolarization of the luminescence of GaAs in a magnetic field at $E_{h\nu}$ = 1.55 eV. The degree of polarization ρ is given in arbitrary units.

Figure 1 shows a plot of ρ against the energy $E_{h\nu}$ of the exciting-light quanta at 77°K, obtained for excitation through a manochromator. The width at half-height of the exciting-light was approximately 100 Å. The figure shows also the theoretical curve calculated for GaAs by M.I. D'yakonov and V.I. Perel'. The curve corresponds to the case when the time of the spin-lattice relaxation $\tau_s \gg \tau$, where τ is the electron lifetime in the conduction band. The kink on the theoretical curve at $E_{h\nu}$ = 1.84 eV is connected with the inclusion in the optical transitions of the $^2\Gamma_7$ band, which is shifted relative to $^4\Gamma_8$ by an amount equal to the spin-orbit splitting Δ = 0.33 eV. Since the transitions $^2\Gamma_7 \rightarrow {}^2\Gamma_6$ produce a predominant orientation of the electron spins in the direction of M, the resultant degree of orientation P decreases with increasing $E_{h\nu}$. A corresponding decrease of ρ should be observed. The maximum value ρ = 25% corresponds to excitation at k = 0 and to luminescence, as a result of the interband electronic transition $^2\Gamma_6 \rightarrow {}^4\Gamma_8$. If the orientation was produced by $\sigma^\pm$ light, one can observe also $\sigma^\pm$ polarization in the luminescence, since the ratio of the probabilities of the transitions $\mp 1/2 \rightarrow \mp 3/2$ and $\mp 1/2 \rightarrow \pm 1/2$ is 3:1. As seen from Fig. 1, the experimentally obtained variation of ρ with increasing $E_{h\nu}$ agrees qualitatively with the theoretically predicted one. However, in the entire $E_{h\nu}$ range we have $\rho_{exp} > \rho_{theor}$. This disparity can have two causes: 1) the influence of the spin-lattice relaxation, 2) the experimentally observed luminescence corresponds not to an interband transition, but to transitions from the conduction band to acceptor levels.

In our case, the acceptors can be regarded as a sufficiently shallow impurity, since its levels are approximately 0.1Δ away from $^4\Gamma_8$. The wave functions of such an impurity coincide with the wave functions of the upper valence band $^4\Gamma_8$. In this case the experimentally observed decrease of ρ from the theoretical one should be ascribed to the influence of spin relaxation. Allowance for this relaxation leads to a decrease of ρ by a factor $\tau_s/(\tau_s + \tau)$ which becomes noticeable if τ_s is comparable with τ. A faster decrease of ρ_{exp} compared with ρ_{theor} apparently indicates that τ_s decreases with increasing $E_{h\nu}$. From the deficit $\Delta\rho = \rho_{theor} - \rho_{exp}$ we can estimate τ_s if we know τ.

Observation of luminescence depolarization under the influence of a magnetic field $\vec{H}$ makes it possible to obtain a second equation relating τ with τ_s, and thus determine both quantities. Figure 2 shows the experimentally observed points of the $\rho(\vec{H})$ plot. The solid curves represent the Lorentz function $1/[1 + (\omega T)^2]$, where ω is the precession frequency and $1/T = 1/\tau_s + 1/\tau$ [3]. The value of T obtained from the experimental plot is accurate to within the g-factor ($h\omega = g\mu_B\vec{H}$, where μ_B is the Bohr magneton and amounts to $(4.9 \pm 0.4) \times 10^{-11}$ sec/g. If we choose for the g-factor the value 0.5228 ± 0.0001 obtained from measurements of the EPR of n-GaAs [5], then T = $(9.4 \pm 0.8) \times 10^{-11}$ sec. Then $\tau_s = (\rho_{max}/\Delta\rho)T = (2.8 \pm 0.6) \times 10^{-10}$ sec and $\tau = (\rho_{max}/\rho)T = (1.5 \pm 0.2) \times 10^{-10}$ sec.

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THERMAL EXPLOSION INDUCED IN A COLLISIONLESS PLASMA BY A RELATIVISTIC ELECTRON BEAM

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Experimental investigations of the interaction between a relativistic electron beam and a plasma were performed with the setup whose scheme is shown in Fig. 1. A hydrogen plasma ($n_0 \sim 10^{11} - 10^{14}$ cm^{-3} was produced in cylindrical glass tube 1 of 20 cm diameter and 300 cm length, by discharging low-inductance capacitors through six "surge" turns 2 surrounding the outer diameter of the tube. The quasistatic magnetic field H_0 produced by the turns 3, with 30 cm diameter, was varied from 0 to 2.5 kOe.

The beam sources was the Rius-5 electron accelerator 4 developed in E.A. Abramyan's laboratory of our institute and described in [1]. The beam was introduced into the magnetized plasma by means of coil 5, which produced a magnetic field frozen into the cathode and was superimposed on the field H_0 so as to produce a magnetic-mirror configuration (such a configuration was produced on the opposite end of the plasma volume with the aid of doubled turns 12 having a smaller diameter). Under the experimental conditions, the maximum energy of the electrons in the beam reached 3 - 4 MeV, the maximum current was 10 - 15 kA, and the current duration was $\sim$50 nsec.

The initial density n_0 was registered by means of a microwave interferometer (λ = 8 mm, 3 cm, 6 cm). The heating of the plasma due to the passage of the beam was measured with external diamagnetic probes 7 in sections distributed along the tube axis z. The microwave noise was registered at several sections (9) in the 1.5 - 6 cm band. The beam current at the output of the accelerator and the total current in the plasma were registered with Rogowski

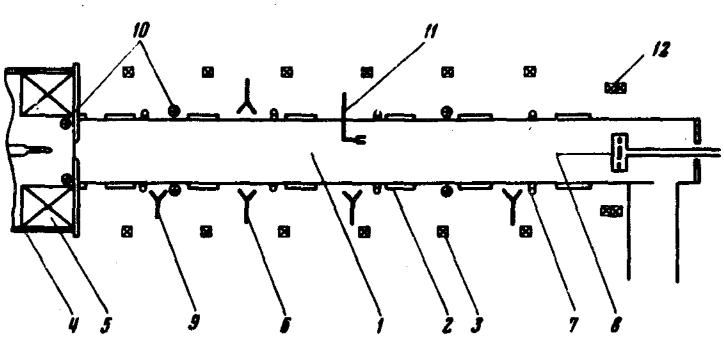

Fig. 1. Diagram of experimental setup.