$$\sigma \sim T^{-5/4} \text{ for } \left(\phi_0 \frac{d}{l_\theta}\right)^{-1} < \frac{T}{\theta} < \left(\phi_0^3 \frac{l_\theta}{d}\right)^{1/5}.$$

Comparison with experiment [1] apparently favors a $q(\Psi)$ dependence of the "step" type (formula (6a)).

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INVESTIGATION OF THE RADIATION OF STRONG-CURRENT PULSED DISCHARGES IN METAL VAPOR IN THE VACUUM ULTRAVIOLET REGION

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A specially developed photoemission-scintillation analyzer is used to investigate the radiation of strong-current pulsed discharges in Li and In at quantum energies 10 - 100 eV. The measured spectra reveal maxima connected with recombination of the ions LiIII and in II, inIII, and inIV.

In a number of problems connected with the investigation of a dense radiating discharge plasma, great interest attaches to measurements of the distribution of the radiation up to quantum energies $h\nu \sim 100$ eV. The use of diffraction spectrometers in measurements of this kind is made difficult both by their low efficiency (the minimum total number of registered quanta is 10^{14} $cm^{-2}sr^{-1}$ phen photography on film is used [1]) and by the contamination of the grating by the discharge products. We have measured the radiation distribution of strong-current pulsed discharges in Li and In vapor at quantum energies 10 - 100 eV. The parameters of these discharges (I_{max} = 220 kA, $\tau_{1/2}$ = 70 μsec, $N \approx 10^{18}$ cm^{-3}, energy input E = 50 J/cm^3) are given in [2].

The method employed is based on measurement and analysis of the integral spectrum $I = I_0 \int f(h\nu, \theta, \varepsilon) d\theta d\varepsilon$ of the electrons knocked out from the photocathode by direct radiation from the plasma. To this end, a planar grid analyzer transmitted to the detector, from the total photoelectron flux I_0, the electrons with energy $\varepsilon \geq eU_R$, where U_R is the retarding potential of the grid. The electrons passing through the grid were accelerated to 15 kV and registered by a scintillator + light pipe + photomultiplier system (Lincke detector [3]). The photomultiplier signal was recorded with an oscilloscope. The chosen time resolution was $\Delta\tau$ = 1 μsec, and the efficiency of the instrument was 10^{11} quanta-$cm^{-2}sec^{-1}$. A detailed description of the analyzer is given in [4].

The experimental results, $I/I_0 = f(U_R)$, are shown in Fig. 1. They were reduced by using the available data on the energy and angular distributions of the photoelectrons. The latter, as follows from [5], is independent of the quantum energy, at a constant angle of incidence of the quanta, up to an energy on the order of several keV. The energy distribution of the photoelectrons usually contains two smeared maxima [5, 6]. The first is in the 0 - 5 eV region and is due to electrons leaving the photocathode after multiple scattering. The second maximum is

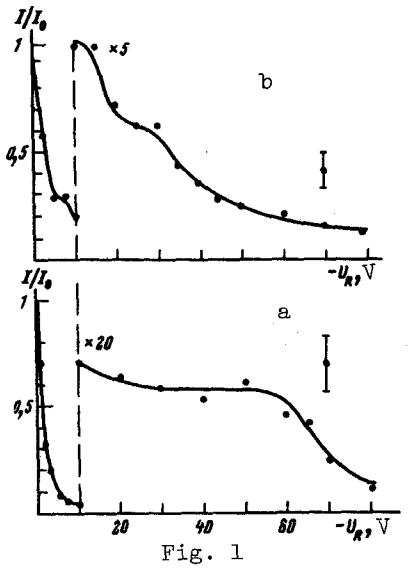

Fig. 1

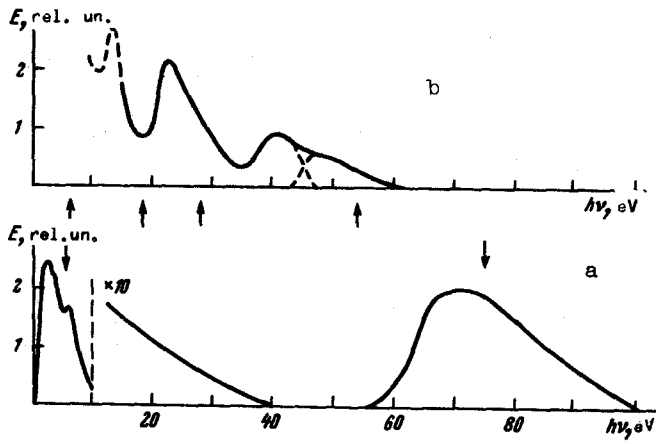

Fig. 2

Fig. 1. Change of photoelectron flux vs the analyzer retarding potential, $I/I_0 = f(U_R)$, for Li plasma (a) and In plasma (b) emission. Rms errors.

Fig. 2. Emission spectrum of Li plasma (a) and In plasma (b). The arrows indicate the ionization potentials

located at the Einstein boundary and is due to the surface photoeffect. The analyzer's ability to resolve separately-standing lines is limited by the contrast of the second maximum. In our case, the role of both maxima is determined from the measurements on the lithium plasma. The emission of the Li plasma in the quantum energy region 20 - 100 eV can be due to recombination of Li III ($h\nu \geq 75$ eV) and emission in the resonance lines of Li II* ($h\nu \sim 60$ eV), as indicated by the numerical calculations in [7]. A decrease of the optical desnity was observed in [8] when the quantum energy was increased from 3 to 10 eV; this decrease should lead to an almost complete absence of emission in the 20 - 60 eV region. Emission with $h\nu \simeq 60$ eV and with $h\nu \gtrsim$ eV appears therefore in the electron spectrum if the second maximum has sufficiently good contrast. This is confirmed by experiment - Fig. 1a has a horizontal section of I/I_0 at U_R from 20 to 60 V. The width of the second maximum of the photoelectrons was determined on the spectrum section 70 - 50 V, where a smooth rise is observed from the inflection point corresponding to the peak of the Li III recombination to the horizontal line. This width does not exceed 10 V, and therefore intervals $\Delta U_R = 5$ V were sufficient to register the recombination continua of Li and In.

The far-ultraviolet emission pulse duration was ~20 μsec, and the maximum of the pulse corresponded in time to the maximum of the power input to the discharge.

The conversion from the electron to the photon spectrum was by numerical differentiation with a correction for the work function 5 eV and the quantum yield for gold, taken from [9, 10]; the fraction of the surface photoeffect was assumed constant over the entire measured region. The obtained spectra are shown in Fig. 2.

Concluding the description of the experiment, we note the simplicity and high sensitivity of the method (at least two orders of magnitude higher than that of diffraction spectrographs with photoelectric registration of the quanta).

The character of the measured spectrum and the amplitudes and shapes of the maxima correspond to the recombination continuum calculated assuming hydrogen-like cross sections for the Li and In ions. According to estimates, the intensities S of indium plasma emission are related like S(InII):S(InIII):S(InIV) = 2:1:1.2, which agrees qualitatively with the measured 1.3:1:0.4. The shift of the recombination peaks to the left of the arrows, by about 5 eV, is due to the width of the second maximum of the photoelectrons. The smearing of the recombination peak of InIV is possibly caused by the resonance line with $h\nu = 35$ eV. For the Li plasma, the intensity

of the group of lines LiII* with $h\nu \approx 60$ eV is estimated to be small, and is therefore indistinguishable against the recombination background. The spectrum in the region 0 - 10 eV was taken from [8] and makes it possible to determine the energy of the recombination radiation of LiIII. Its share is 6¢ of the total emission energy 17 kJ, and corresponds to $T_e = 5$ eV in the central part of the discharge [11]. Thus, a plasma with $N \approx 10^{17} - 10^{19}$ cm^{-3} and $T_e = 2 - 10$ eV emits in the far-ultraviolet region mainly in energy intervals dictated by electron recombination to the ground states of doubly, triply, and more multiply charged ions. Such a plasma can werve as a powerful source in the far ultrviolet, and owing to the selective emission spectrum the required energy input is about one-hundredths the black-body value. The intensity of the investigated source, $\sim 10^{22}$ quanta-cm^{-2}sec^{-1} is much higher than that of the known sources (T-tubes, Penning discharge, etc. [1]).

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MODULATION OF LIGHT BY NONEQUILIBRIUM OPTICAL PHONONS IN n-GaAs

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Modulation of light near the direct-transition edge was observed in strong electric fields in doped n-GaAs with $n = 2.4\times10^{16}$ cm^{-3} at $T_0 = 77$°K. The experimental results are compared with a calculation based on the model of direct exciton transitions with participation of nonequilibrium LO phonons. It is shown that within the framework of the employed model it is possible to obtain qualitative and quantitative agreement between theory and experiment if the lifetime of the long-wave LO phonons is assumed to be 0.8×10^{-12} sec.

The main mechanism of energy transfer from the hot electrons to the lattice in polar semiconductors is emission of longitudinal optical (LO) phonons by the electrons. The number of phonons in the crystal then increases, and this can lead to an increased absorption in strong electric fields near the direct-transition edge with participation of LO phonons [1]. This phenomenon was observed and investigated in n-GaAs. The n-GaAs samples, with fused-in contacts, had a dumbell shape with thickness 200 μ along the light-propagation direction. The drift mobility of the electrons at $T_0 = 77$°K was $\mu = 7000$ cm^2/V-sec, the electron density was $N_e = 2.4\times10^{16}$ cm^{-3}, and the strong-field pulse duration was 0.1 μsec. In weakly-doped samples ($N_e \approx 10^{14}$ cm^{-3}), no modulation was observed. The experimental results for two fields are shown in Fig. 1. The absorption threshold lies at an approximate quantum energy $\hbar\omega_{thr} = \varepsilon_g - \varepsilon_{ex} - k_B\theta$ (θ is the temperature of the long-wave LO phonons, ε_{ex} is the exciton binding energy in the ground state).

Light absorption in CdTe in transitions to the exciton states with absorption of equilibrium LO phonons was investigated in [2]. In analogy with [2], we calculated the change in the absorption with participation of LO phonons. We first obtained the nonequilibrium distribution