following: (i) The manganese in germanium is a suitable impurity for the observation of recombination waves; (ii) the period of the observed oscillations does not depend on the sample length; (iii) it follows from [1] that prior to the occurrence of the oscillations the current-voltage characteristic should be close to linear, as was indeed observed in our experiments; (iv) the order of magnitude of the critical field and of the oscillation period turns out to be, at the temperatures and concentrations indicated above, the same as expected theoretically. Further experiments, which are now under way, will make it possible to establish finally the nature of the described oscillations.

In conclusion, we are sincerely grateful to O. V. Konstantinov, V. I. Perel', and G. V. Tsarenkov for stimulating the present experiments, for valuable discussions, and for acquainting us with the results of their theoretical calculations.

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STIMULATED LIGHT EMISSION OF A PLASMA-BEAM DISCHARGE

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As is well known, most existing gas lasers are based on the use of different types of discharge at relatively high pressures (10^{-1} - 10 mm Hg) and correspondingly low electron temperatures (T_e = 5 - 6 eV). The electron temperature in pulsed lasers using a rapid pinch [1] reaches $T_e \sim 20$ eV, and this makes it possible to increase the emission intensity appreciably. To increase further the excitation efficiency of ion lines with large excitation potential, it is necessary to raise substantially the electron temperature, so that the plasma electron energy is close to the maximum of the excitation function, i.e., to approximately 50 - 100 eV. To obtain coherent emission in the ultraviolet region it is necessary that a high electron temperature be produced in low-pressure discharges. These two requirements (high temperature at low pressure) are satisfied to a considerable degree by the plasma-beam discharge, the investigation of which has recently been the subject of a large number of both theoretical and experimental papers [2,3]. In such a discharge, the ionization and the excitation of the atoms and of the ions of the gas is effected by the plasma electrons, the energy of which increases rapidly as a result of collective interaction between the electron beam and the plasma, leading to intense excitation of the high-frequency oscillations in whose field the plasma electrons acquire their energy.

In this case, breakdown is attained at much lower pressures than in ordinary discharges, and the plasma electron temperature greatly exceeds the temperature in other discharges, reaching tens and hundreds of kiloelectron volt. The plasma-beam discharge is a strongly unbalanced system. Furthermore, the ion temperature in such a discharge can be raised to several hundred electron volts, a fact that can be used to broaden the band of generated frequencies. All these features of the plasma-beam discharge suggested the possibility of its use for the development of a gas laser. Of course, the lines could be excited with the aid of monoergetic electron beams, but it is obvious that the excitation with the plasma electrons will be more effective, since the densities attainable in electron beams are much lower than in a plasma.

The purpose of the present paper was an experimental confirmation of the possibility of obtaining stimulated emission in a plasma-beam discharge. In this communication we present the results of investigations of stimulated emission in the visible region.

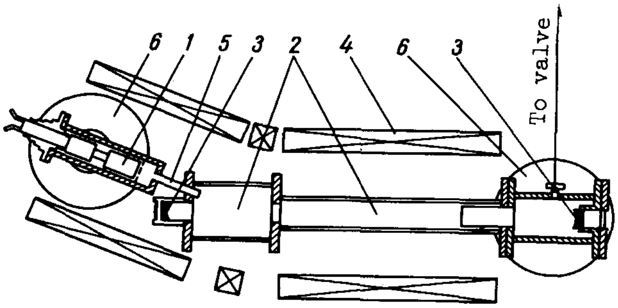

Fig. 1. Diagram of setup: 1 - electron gun, 2 - plasma chamber, 3 - mirror, 4 - solenoid, 5 - pressure-drop tube, 6 - diffusion pumps, 7 - gas-inlet system.

The experiments aimed at obtaining coherent emission were performed with the setup shown in Fig. 1. Electron gun 1, operating in the pulsed mode with pulse duration τ = 40 μsec, injected an electron beam of energy U = 10 - 45 keV and current I = 10 - 30 A into plasma chamber 2 at an angle 15° to the chamber axis. The pulse repetition frequency could be varied from 1 to 50 Hz. The electron beam was injected into the chamber at an angle in order to protect the mirror surfaces against electron or ion bombardment. Inside the plasma chamber was placed a confocal resonator made up of spherical mirrors 3, which were covered with multilayer dielectric coatings. The radius of curvature of the mirrors was R = 10 m, and the transmissions were T = 2% in the 4800 - 5300 Å region and T = 3% in the 4700 - 5700 Å region. The gun and the plasma chamber were placed inside a solenoid 4, on the axis of which was produced a homogeneous magnetic field of intensity 1.5 - 2 kOe. The operating pressure inside the gun chamber 5 was 10^{-5} - 5×10^{-5} mm Hg, whereas the pressure in the plasma chamber could range from 10^{-2} to 10^{-5} mm Hg. Such a pressure differential between chambers was attained by using differential pumping. The working gas was commercial argon.

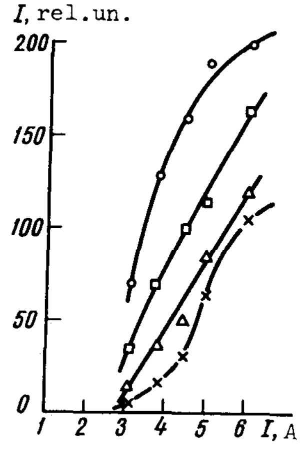

Fig. 2. Intensity of coherent emission (in relative units) vs. gun current (in amperes).

The plasma electron density was measured by the microwave signal cutoff method and reached 10^{12} cm^{-3}. The electron temperature was measured by a spectral method against the relative intensity of the He 4713, 4922, and 5047 Å lines, and reached

$T \sim 90$ eV. The ion temperature was measured with an ISP-51 spectrograph crossed with an interferometer, and equaled $T_i \sim 1$ eV.

Lasing was effected in the described setup in the visible blue-green region at the singly-ionized argon lines 4545, 4579, 4609, 4658, 4880, 4965, 5017, and 5145 Å. The measured divergence of the light beam did not exceed 40". The plasma parameters (electron and ion temperature, density) were regulated by varying the beam parameters (current, energy) and the pressure in the plasma chamber.

Figures 2 and 3 show respectively the emission intensity as functions of the beam current and of the pressure in the plasma chamber. The maximum coherent-emission intensity at 8×10^{-4} - 2×10^{-3} mm Hg (Fig. 3) coincides with the maximum intensity of the high-frequency oscillations excited upon collective interaction between the electron beam and the plasma, and with the maximum of the electron and ion temperature. This correlation is explained by the fact that the rise in the electron and ion temperatures is due to the electric field excited as a result of the instability development. The optimal value of the magnetic field intensity on the plasma-chamber axis was 1.5 kOe. The duration of the generation pulse at the 4880 Å line was $\tau = 30$ μsec, and the pulse power reached 100 W. It should be noted that the lasing was produced in tubes of 20 mm diameter, and the generation power did not change appreciably when tubes with larger diameters, up to 85 mm, were used.

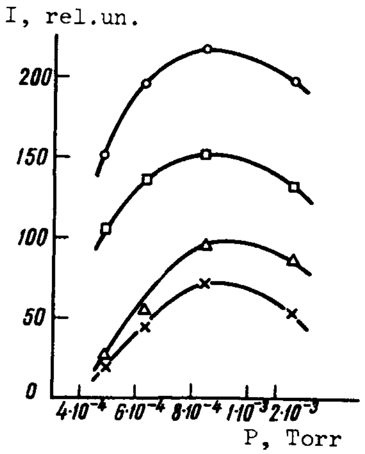

Fig. 3. Intensity of coherent emission (in relative units) vs. pressure.

Our future investigations call for increasing the generation power, broadening the range of generated lines, and a detailed investigation of the inversion mechanism in the plasma-beam discharge.

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PHOTOEFFECT ON NEGATIVE CHARGES IN LIQUID HELIUM

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Results of experimental observation of the photoeffect on negative charges in liquid helium were recently published [1]. The plot of the photocurrent against the wavelength λ of the incident light consitutes a series of alternating maxima and minima, the positions of which on the experimental curve agree with the theoretical calculations for an electron