pulse duration τ decreases monotonically; the radiation power then changes insignificantly and amounts to approximately 100 kW at τ = 200 nsec and 50 kW at τ = 500 nsec (without the semiconducting plates the generation power is 3 MW at τ = 30 nsec). It is possible to obtain stable emission pulses with duration up to 0.7 msec, and the spatial structure of the radiation is improved thereby.

Inside the resonator are placed two plates of a two-photon absorbing semiconductor (Fig. 1), for if one plate is placed between the output mirror and the active crystal, the lasing pulse has an appreciable overshoot at the beginning, connected with lasing due to reflection from the end face of the active element. On the other hand, if the semiconducting crystal is placed between the prism and the active element, then the main single pulse is accompanied by free-running radiation generated in the resonator made up of the end face of the active element and the output mirror. In this case, a decrease of the monopulse duration is observed. It is apparently possible to use one two-photon absorbing crystal, provided the end faces of the active element are cut at the Brewster angle.

The use of amplifiers makes it possible to obtain radiation of large power and of adjustable duration. We obtained a power gain by a factor of 4 using a neodymium-glass amplifier (crystal length 120 mm).

It is apparently possible to choose semiconducting materials capable of regulating the generation-pulse durations of all generators. In particular, the experimental results of Zubov et al. [4] show that germanium can be used as this material for a dysprosium laser.

It should be noted that the method used in the present investigation can be employed to vary the pulse duration of lasers operating in the mode-synchronization regime (picosecond range).

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EMISSION PRODUCED BY EXCITED HELIUM MOLECULES WHEN SOLID TARGETS ARE BOMBARDED BY MEANS OF FAST HELIUM IONS

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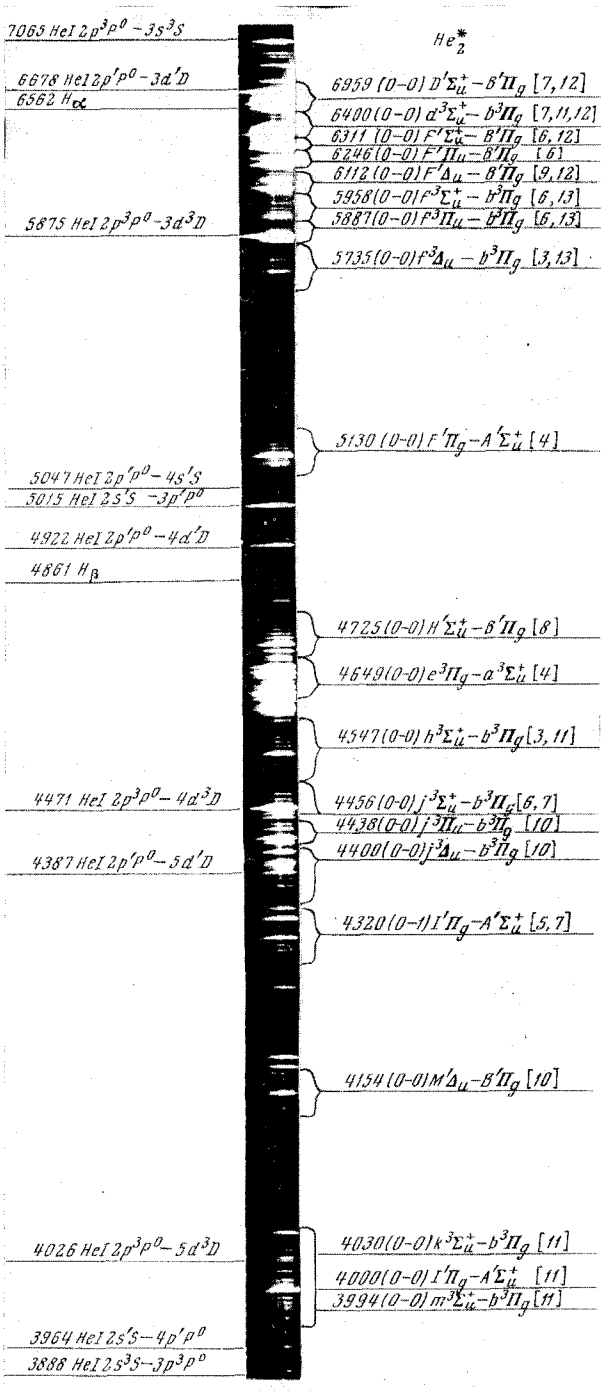
It was established in our earlier paper [1] that bombardment of a metallic target with fast hydrogen ions produces a glowing halo extending 1 - 1.5 cm from the surface of the target. It was shown that this glow is due to the emission by the fast hydrogen atoms when the ions of the primary beam are scattered by the surface of the target. In the present communication we present the results of an investigation of the glow produced when a number of

solid targets are bombarded with beams of fast helium ions.

When a beam of He^+ ions with energy 20 keV and current density 300 mA/cm^2, separated by a magnetic analyzer, is incident on a target, a glowing halo is produced near the target and appears immediately after the start of the target bombardment. The general character of this halo is the same as when hydrogen ions are used for the bombardment (see the figure of [1]). The glowing region extends ~1 cm from the surface of the target. The spectrum of this glow, obtained with the aid of an ISP-51 spectrograph in a direction perpendicular to the plane between the beam axis and the normal to the surface of the target, consists of a number of lines of the helium atom. The wavelengths of these lines and the corresponding transitions are indicated in the figure. The Doppler broadening of the lines of the He I spectrum and the appreciable size of the halo indicate that these lines are emitted by fast excited helium atoms, produced during the course of the scattering and neutralization of the primary ions when they interact with the surface of the target.

Further observations have shown that, besides the glow of the rapidly excited helium atoms, a new glow, located very close to the surface of the target, appears after a certain time, which may reach several hours. The spectrum of this glow, observed at an angle 45° to the normal to the target surface (the beam of He^+ ions was also inclined 45° to the normal), consists of a number of bands (see the figure) [1]. A determination of the wavelengths of the quanta of the bands, and also of the wavelengths of the rotational-structure lines,



Emission spectrum of excited helium molecules produced by bombarding a graphite target with 20-keV He^+ ions. The beam current is 10 μA. The exposure time is 3 hrs after 10 hrs of preliminary target irradiation.

[1] This spectrum contains also He I lines, since not only the surface glow but also the glow of the halo enters the slit of the spectrograph.

wherever the structure was sufficiently resolved, showed that the near-surface glow was emitted by excited helium atoms. The wavelengths indicated in the figure, determined from a number of spectra obtainted in the present study, coincide within the limits of the measurement errors with the corresponding wavelengths, determined from the molecular spectra of helium, emitted by a condensed helium discharge plasma [2-13]. We can apparently conclude therefore that the emission observed in the present paper is produced by the excited helium molecules after they have moved away from the surface of the target. The very small thickness of the glow, which produces a band spectrum, indicates that the excited helium molecules have relatively low velocities.

A spectrum similar to that shown in the figure (produced by bombarding a graphite target with He^+ ions) was obtained also by bombarding targets of other materials (Ni, Pt, Pd). However, prolonged bombardment by the ion beam produced on the surfaces of these targets a film of free carbon [1]), and therefore the influence of the target material on the process of formation of the excited helium molecules could not be established in these cases.

We can advance the following preliminary considerations with respect to the production of excited helium molecules by target bombardment with a beam of He^+ ions. From experiments on the penetration of ions in metallic films [14] it is known that the penetrating particles first accumulate at a certain depth under the surface of the target, a depth equal to the mean free path of the ions in the target material. With increasing irradiation dose, the region of appreciable concentration of the penetrating particles broadens, and it ultimately reaches the surface of the target. The glow of the excited helium molecules appears apparently at the instant when the knocked-out helium atoms begin to emerge from the surface of the target.

There are two possible mechanisms for knocking out the excited helium molecules from the surface of the target.

1. The helium atoms in the field of the adsorption forces produce on the surface of the target a stable He_2 molecule in the electronic ground state [2]. The ion beam incident on the surface of the target imparts to the He_2 molecule the excitation energy and the momentum necessary for it to leave the target surface.

2. The helium particles diffusing on the surface of the target are in the atomic state. Some of these helium atoms, owing to bombardment by the ion beams, are excited. Owint to the recombination of the excited and the non-excited helium atoms, excited helium molecules are produced [3]. The momentum imparted to these molecules at the end of the collision cascade, due to the penetration of the primary ion into the beam, causes these molecules to move away from the surface of the target.

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1) These carbon films are the result of disintegration of the molecules of the hydrocarbons adsorbed on the surface target by impact of the bombarding-beam ions.

2) As is well known, isolated He_2 molecules are not stable in the electronic ground state.

3) The formation of the excited helium molecules in this recombination process determines the kinetics of the afterglow in the decaying helium plasma [15].

In conclusion, it should be indicated that continuous emission in the region of the vacuum ultraviolet should be observed when solid targets are bombarded by a beam of helium ions. This emission will arise when the excited He_2 molecules go over to the unstable ground state.

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THREE-LEVEL GAS LASER [1)]

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1. We describe here a gas laser in which the gain necessary for lasing is produced by external radiation from another laser. We investigated the pair of transitions $3s_2 - 2p_4$ ($\lambda_1 = 0.63\ \mu$) and $2s_2 - 2p_4$ ($\lambda_2 = 1.15\ \mu$) of neon (Fig. 1). An external field at $\lambda = 0.63\ \mu$, resonant with one of the two neighboring transitions $3s_2 - 2p_4$, produces a dip in the velocity distribution of the atoms at the common level $2p_4$ (the Bennett hole [1]). As a result, the gain line at the $2s_2 - 2p_4$ transition represents a narrow Lorentzian peak. It is important that this peak is produced by atoms whose velocity projections on the direction of propagation of the external field lie in the narrow interval $\Delta v \approx (\gamma_{3s_2} + \gamma_{2p_4})/k_1$, where γ is the level width and k_1 the wave number. The spectral characteristics of the laser at $\lambda = 1.15\ \mu$ differ greatly in this case from those observed so far in gas lasers, since the lasing at $\lambda = 1.15\ \mu$ is realized, as it were, by an atomic beam. However, the complete analogy with the atomic beam is limited by the nonlinear effects of the interaction of the resonant fields in the quantum system [2-5], which lead to a change in the line shapes of the emission and absorption of the weak field in the presence of the strong one. For moving atoms, this interaction causes the shapes of the emission and absorption lines of the $2s_2 - 2p_4$ transition to become dependent on the direction of the field propagation (nonlinear

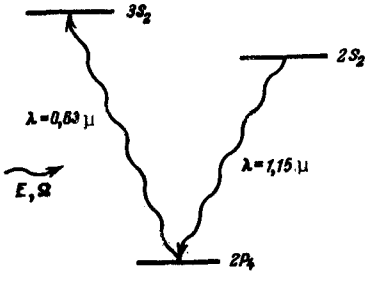

Fig. 1. Working-level scheme

[1)] Reported at the All-union Symposium on Nonlinear Optics, Kiev, October 1968.