to the vibrational level v' = 1 approximately 45% of the particles. It must be noted that the pumping of the ammonia occurs through one vibrational-rotational transition of the molecule. Direct measurements of the absorption of infrared light in ammonia also show that 45% of the particles are at the upper vibrational level. Thus, during the course of the CO_2-laser pulse, the molecules excited by the laser radiation becomes photodissociated. During the cooling of the ammonia, there is likewise photodissociation of the molecules from the upper vibrational level, but there is no two-step process. This stage of photodissociation of non-selectively excited molecules can be avoided by applying the UV radiation in the form of a short pulse. The number of photodissociated ammonia molecules was not measured in the described experiments.

Two-step photodissociation of molecules makes it possible to effect selective photodissociation in a gaseous mixture of molecules whose photodissociation energies practically coincide.

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CROSS SECTIONS FOR THE EXCITATION OF Ar II LASER LINES IN ELECTRON-ION COLLISIONS

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An investigation of the lasing mechanism in an argon-ion cw laser [1 - 3] shows that the predominant contribution to the population of the upper laser levels should be made by electronic excitation from the ground state of the ion. To be sure, this conclusion is based on the use of the argon-ion excitation cross sections calculated in the Born-Coulomb approximation for transitions between electronic configurations, and not between the corresponding energy levels of the ion. It is therefore very important to measure in the experiments the argon-ion excitation cross section at low electron energies. Investigations of this kind, however, are extremely difficult. This is evidenced by the experimental papers published to date, in each of which the investigation is limited to the excitation of only one level or one line with the highest probability, namely, the $He^+(2s)$ metastable level [4] and the resonance lines of Ba II [5] and Ca II [6].

We have constructed in our laboratory a large-scale mass-spectrometric setup with interesecting electron and ion beams, for the investigation of excitation of various ionic objects by slow electrons in a wide range of emitted wavelengths. We report here experiments on the excitation of a group of laser lines produced by direct collision of electrons with argon ions in the ground state, i.e., in the process

$$e + Ar^+(3p^5) \rightarrow Ar^{+*}(3p^4 4p) + e. \qquad (1)$$

The argon ions were drawn by an electric field from the source and separated in accord with the e/m ratio in the mass spectrometer with a non-uniform magnetic field. The ion beam formed by a system of rectangular slits intersected

the electron beam at right angles. The argon ion concentration in the region of the beam intersection, at an energy 15 keV, was $\sim 2 \times 10^8$ cm^{-3}, and the density of the electron current, in the energy range 10 - 100 eV, was $(3 - 5) \times 10^{-3}$ A/cm^2. The electron energies were uniform within $\sim$2 eV. The spectral resolution of the excited ions was effected with an MDR-2 monochromator. The relative brightness of the investigated line was registered with a photomultiplier operating in a regime in which individual photoelectrons were counted.

The limiting pressure of the residual gases in the differentially-evaluated collision chamber was 5×10^{-8} Torr. Under the operating conditions the pressure increased to 5×10^{-7} Torr, owing to the neutralization of the ions on the surfaces and in the receiver, and also because of the gas effusion of the argon from the ion source. Under such conditions, the concentration of the neutral gas particles (mostly argon) in the collision chamber was higher by almost two orders of magnitude than the concentration of the argon ions in the beam. The separation of the useful signal (process (1)) must therefore be carried out against an appreciable background of radiation having the same wavelength and due to the collisions of the electrons and ions with the argon atoms, and also with the molecules of the atmosphere gases, namely:

$$e + Ar(3p^6) \rightarrow Ar^{+*}(3p^4 4p) + 2e, \quad (2)$$

$$Ar^+(3p^5) + Ar \rightarrow Ar^{+*}(3p^4 4p) + Ar, \quad (3)$$

$$Ar^+(3p^5) + M \rightarrow Ar^{+*}(3p^4 4p) + M. \quad (4)$$

In the general case we used for this purpose a procedure wherein both beams were modulated. In this particular case (excitation of Ar^+), however, we could confine ourselves to modulation of the electron beam only (owing to the relatively high threshold of the process (2)). It was effected by rectangular pulses with synchronous registration of the pulse signals from the photomultiplier in two scalar channels. This procedure made it possible to investigate the excitation of the ions by electron impact, up to energies corresponding to the threshold of the reaction (2) (i.e., up to $\sim$35 eV). In this energy range, we have measured, for the first time, the excitation functions and determined the efficiency of excitation of four laser transitions of Ar II from the levels $4p^2P^0_{1/2}$, $4p^2P^0_{1/2}$, $4p^2D^0_{3/2}$, and $4p^2D^0_{5/2}$, the excitation potentials of which are respectively 19.80, 19.87, 19.76, and 19.68 V.

The energy dependences of the excitation cross sections of the investigated lines are shown in Figs. 1 and 2. The curves show the 90% confidence interval (vertical segments) of the relative measurements of the excitation functions, and the dashed lines show the excitation thresholds of the upper levels of the corresponding transitions. The absolute cross sections were obtained by calibrating the registration system against the known excitation cross sections of the investigated transitions from the ground state of the argon atom, i.e., process (2) [7]. We have introduced here a correction that takes into account the fraction of the excited ions radiating in the cutoff region of the photon detector, as a function of their velocity and of the lifetime of the excited states. The rms error in the determination of the effective excitation cross section is ±40%.

As seen from the figures, a characteristic feature of the excitation of these transitions is the presence of two maxima, the first at the threshold of the process and the second in the electron energy region 28 - 29 eV. Obviously, if the electrons can be made more monokinetic, the first maxima on the curves will shift towards the excitation thresholds, and the values of the cross sections at the threshold will increase accordingly.

The results show that the efficiency of excitation of the Ar II laser lines by slow electrons from the ground state of the ion is 15 - 30 times higher than

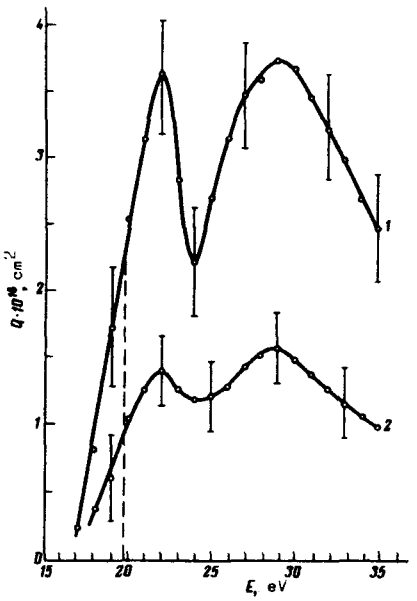

Fig. 1

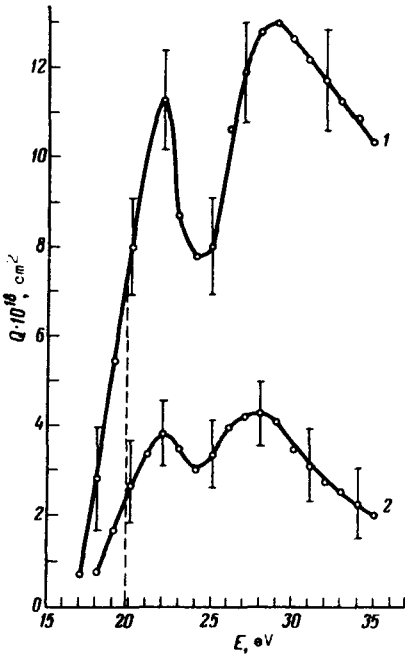

Fig. 2

Fig. 1. Absolute excitation functions of the Ar II lines λ 4658 Å ($4s^2P_{3/2} - 4p^2P^0_{1/2}$) and λ 4545 Å ($4s^2P_{5/2} - 4p^2P^0_{3/2}$).

Fig. 2. Absolute excitation functions of the Ar II lines λ 4880 Å ($4s^2P_{3/2} - 4p^2D^0_{5/2}$) and λ 4965 Å ($4s^2P_{1/2} - 4p^2D^0_{3/2}$).

the maximum efficiency of excitation of the same lines from the ground state of the neutral atom. Thus, the results of our experiments confirm quantitatively that the main contribution to the population of the working levels of the argon laser is made by the process of excitation from the ground state of the ions by electrons of a gas-discharge plasma.

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