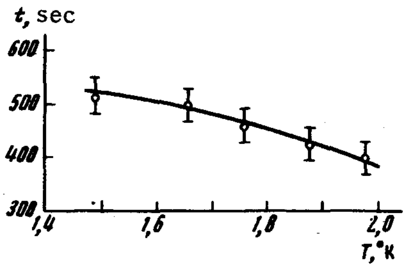

Fig. 2. Relaxation time t vs the temperature T of He-II when the rotary speed of the vessel is decreased from $\omega = 0.029$ sec^{-1} to $\omega = 0.012$ sec^{-1}.

and then assumes the new equilibrium value relatively rapidly [1, 2].

It follows from these observations that the decay of the vortex system when the rotation of the helium II stops differs strongly from the decay of the excess vortices following a sudden decrease of the rotary speed. Whereas in the former case the system responds instantaneously to the change of the conditions and starts immediately to go over to the new equilibrium state, in the latter case the system stays for a long time in a metastable state.

We note finally that our results, like the results of [1, 2, 7], serve as an additional argument favoring a new hypothesis recently advanced by Packard [9], that the acceleration (starquake) of pulsars is connected with the metastability of the vortex lattice of superfluid neutron liquid.

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GAS LASER USING IONIZED EUROPIUM

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A high-power pulsed and quasicontinuous lasing was obtained using singly-ionized europium in the near infrared. The laser has high efficiency. New promising conditions for gas-laser excitation are found.

The use of metal vapors as active media in gas lasers has led to the development of high-efficiency and high-power lasers in the visible band [1]. A large group of metals, however, has not yet been investigated or used in gas lasers, including the series of rare-earth elements. At the same time, the diversity of energy-level structures of the atoms and ions of rare earth make them promising for the development of new highly efficient active media.

In the present study, by investigating electric discharges in mixtures of rare-earth metal vapors with inert gases, we obtained for the first time lasing on a number of lines of singly-ionized europium. The upper levels of the new laser belong to the configurations $4f^76p^9p$, ^7P, and the lower ones to $4f^75d^7D^0$ of Eu II. Under near-optimal excitation conditions we observed simultaneous lasing on three powerful lines with wavelengths $\lambda = 1.002$ μ ($^7P_4$ - $^7D_0$), $\lambda = 1.0166$ μ ($^7P_4$ - $^7D_4^0$), and $\lambda = 1.361$ μ ($^9P_4$ - $^7D_5^0$) (we used the energy-level systematics from [2]). Lasing on other lines between levels of the indicated configurations is observed when a grating is introduced into the laser resonator.

A column of Eu vapor was obtained in the resistance heater of a gas-discharge tube made of BeO ceramic, 50 cm long and with inside diameter 0.7 cm. The working mixture consisting of Eu vapor and helium was excited by current pulses of duration from 3 to 600 μsec and amplitude from 2 to 400 A. The transitions were identified both by direct measurements of the generation-line wavelengths and by modulating with stimulated emission the intensities of the spontaneous lines having common levels with the generation lines.

The conditions for the onset of population inversion on the europium ions are characterized by a narrow temperature of the cell with the metal, viz., $t_{opt} \pm 25°C$, where t_{opt} is the temperature corresponding to the maximum energy in the pulse and is equal to 600, 610, and 620°C for $\lambda = 1.002$, 1.0166, and 1.361 μ, respectively. The equilibrium vapor pressure of Eu in the working cell temperature interval (580 - 650°C), calculated from the elasticity equation [3], ranged from 3×10^{-3} to 9×10^{-3} Torr.

Lasing at $\lambda = 1.361$ μ was observed at any He pressure in the range from 1 to 650 Torr (see the figure), and starting from 200 Torr for the 1.002 μ and 1.017 μ lines. The optimal He pressure for all lines was 600 - 650 Torr. At higher concentrations the decrease of the radiation energy on all lines was connected not with the mechanism that produced the inversion but with the instability of the longitudinal discharge.

The lasing pulse duration for all transitions was equal to the duration of the spontaneous emission from the upper laser levels and amounted to 3 - 150 μ sec, depending on the excitation conditions. The maximum energy in the pulse was 0.6×10^{-3} J for $\lambda = 1.002$ μ and $\lambda = 1.0166$ μ and 0.4×10^{-3} J for $\lambda = 1.361$ μ, at a tube working volume 20 cm^3. The maximum pulse power was 50 W. The gain for $\lambda = 1.002$ μ exceeded 20 dB/m, so that a plane-parallel quartz plate could be used as the output mirror of the resonator. The gains for $\lambda = 1.0166$ μ and $\lambda = 1.361$ μ were 10 and 15 dB/m, respectively.

The quantum efficiency of the Eu II laser is 14 - 15% when the upper levels were excited from the ground state of the atom. The attained electric efficiency of the laser is 0.6%. The threshold current density determined for $\lambda = 1.002$ μ is 5 A/cm .

The conditions for the excitation of an Eu II laser being characterized by a very high buffer-gas pressure are unusual for lasers based on metal vapor, and all the more for ionic lasers; they seem to have been realized here for the first time. These conditions are promising, on the one hand, for the development of high-power single-frequency lasers, since the gain line contour at such a high pressure is close to the dispersion contour, and on the other hand for the development of "collision" lasers using metal vapors [4].

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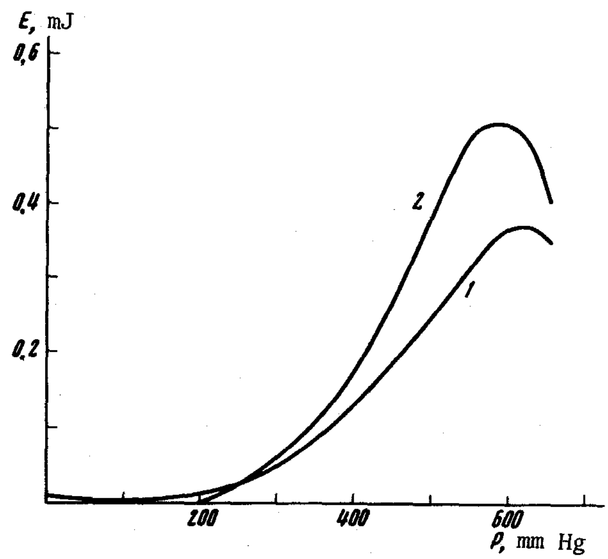

Generation pulse energy vs helium pressure at $\lambda = 1.361$ μ (1), 1.002 μ (2), and 1.0166 μ (3).