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INVESTIGATION OF EMISSION CHARACTERISTICS OF A PHOTODISSOCIATION THALLIUM LASER
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Results are reported of investigations of the spectral and energy properties of the emission of a thallium laser on the transitions 7S1/2→6P3/2 (λ = 535 nm) and 7S1/2→6P1/2 (λ = 377.6 nm). Excited thallium atoms are produced in dissociation of the TII molecule by radiation from an ArF laser (λ = 193 nm). The experiments were performed with two cavity types, to make possible operation with lasing at one or two wavelengths. In the case of operation with one wavelength, the emission spectrum at λ = 535 nm consists of the hyperfine structure components of two isotopes Tl203 and Tl205, whose frequency difference depends on the emission flux density in the cavity. At the λ = 377.6-nm wavelength the isotopic structure of the line is not manifested, since the isotope shift is small compared with the Doppler width. When two wavelengths are generated, it is observed that when a certain flux density is reached the emission structure is qualitatively altered, with unequal changes in the character of the emission spectra of the different lines. The results are discussed.

INTRODUCTION

Photodissociation of molecules can lead to formation of excited atoms and to lasing on corresponding transitions [1]. Much progress was made recently in photodissociation (PD) lasers based on this principle, in view of the use of high excimer energy sources for the photodissociation [2-4]. Interest in the development of PD lasers is due primarily to the possibility of obtaining lasing on resonant lines of atoms, a property quite promising for many applications, such as obtaining reference lines and measurement of impurity densities. Experimental investigations have shown, however, that the PD-laser emission spectrum has a complicated structure that depends on the experimental conditions. Thus, the use of a PD thallium laser in the superradiance regime [2] has shown that at a certain excess of the pump above threshold the spectral composition of the laser emission is doubled, and as the PD lasing power is increased the frequency spacing between the spectral components increases. In the interpretation of the observed phenomenon [5] it is indicated that doubling the spectrum is due to the onset of simultaneous lasing by two thallium isotopes (Tl203, Tl205), and the dependence of the frequency difference between the components on the lasing power is determined by field effects. We have performed similar experiments and obtained results that confirm the explanation proposed. Our investigations are based on the use of optical cavities of various types. This made it possible to increase in the experiments the PD-laser emission flux density, and also to obtain predominant lasing on one green or violet line. We observed in this case changes in the spectral composition of the laser.

emission, as manifest by an increase of the number of spectral components of the lines on the $7^2S_{1/2} - 6^2P_{3/2}$ ($\lambda = 535 \text{ nm}$) transition, and broadening and shift of the lines on the $7^2S_{1/2} - 6^2P_{3/2}$ ($\lambda = 377.6 \text{ nm}$) transition. The main content of this paper is a description of the experimental results of the investigation of the PD thallium laser characteristics and their discussion.

LASING CHARACTERISTICS OF PD LASER

The experimental setup consisted of a pumping laser, a cell with TII vapor in an optical cavity, and a detection system (Fig. 1). The pump source was an ArF laser having a peak power 1.5 MW at a pulse duration 5 nsec at half-maximum. The pumping-laser emission was focused by a lens of focal length $F = 40 \text{ cm}$ and entered the cell through a prism $P_1$. The cell was made of fused quartz and was 6 cm long. An operating temperature $T = 200-500^\circ \text{C}$ was produced by a resistance heater. Two optical-cavity systems were used: dispersive (Fig. 1b) and nondispersive (Fig. 1a). In the dispersive system an additional prism $P_2$ was installed and the lasing power on the green or violet line could be amplified or attenuated by rotating the mirrors $M_1$ and $M_2$. In both cavities, mirror $M_1$ was nontransmitting, while $M_2$ was either a quartz plate or a semitransparent mirror. The cavity was 20 cm long. The temporal and energy characteristics of the PD laser were measured with an F1K-22 photo-receiver, an S1-75 oscilloscope, and an IMO-2 power meter. The spectral composition of the radiation was investigated with Fabry-Perot interferometers having free spectral ranges 75 and 30 GHz. The spectra were photographed on RF-3 film by Tair-300 and MTO-1000 lenses.

The excited Tl* atoms were produced by photodissociation in accordance with the scheme

$$\text{TlJ} + h_\omega \rightarrow \text{Tl}^* + J(2P_{3/2}) + \Delta W_k,$$

where $h_\omega$ is the quantum energy of the pumping excimer ArF laser, and $\Delta W_k$ is the excess kinetic energy of the produced atoms. At a certain pump-radiation flux density the density of the excited thallium atoms in the $7S_{1/2}$ state turns out to be sufficient for the onset of lasing on the resonant transitions $7S_{1/2} - 6^2P_{3/2}$ and $7S_{1/2} - 6^2P_{1/2}$. The energy characteristics of the investigated PD laser (Fig. 3) were obtained by using the nondispersive cavity. Figure 3a shows the dependence of the PD-laser power on the pump-laser power at a cell tem-