GAS LASER EXCITED IN THE PROCESS OF PHOTODISSOCIATION

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New results are reported of an investigation of the parameters of a gas laser, using atomic iodine excited in the process of photodissociation of the molecules CH_3I and CF_3I. The dependence of the emission threshold and of the output energy in a laser pulse on the pressure in the working medium was investigated. It is shown that, in a certain range of pressures, the emission threshold has a minimum. The pressure range for CH_3I is quite different from that for CF_3I.

RAUTIAN and Sobel'man [1] suggested using the photodissociation of molecules as a method of obtaining population inversion and showed that it had advantages over other optical excitation methods. Our attempts to obtain population inversion by the photodissociation of a series of diatomic molecules (NaI, CsI, TlI, InI, and others) were, for one reason or another, unsuccessful. [1)] Some results of these investigations were published in [4,5]. Recently, Kasper and Pimentel published a brief letter [6] on the generation of laser emission using atomic iodine excited in the process of the photodissociation of CH_3I and CF_3I molecules ($\lambda = 1.315\ \mu$, $^2P_{1/2}-{}^2P_{3/2}$ transition).

The present communication reports some results of our investigations of such a laser, which are new in relation to those in [6].

In our first experiments, the excitation source was an argon pulse-discharge lamp, 500 mm long. The lamp was supplied from a source consisting of $C = 50\ \mu F$ at a voltage of 2—10 kV. The working substance (CH_3I or CF_3I vapor) was introduced into a quartz tube (600 mm long, 7 mm bore) with end windows which made Brewster angles with the tube axis. The lamp and the quartz tube were placed next to each other and wrapped with aluminum foil. A confocal resonator with spherical mirrors of R = 1000 mm radius was used. The reflecting gold film had a transmission of less than 1% at $\lambda = 1.3\ \mu$. The emission was recorded with a GeAu photoresistor and a double-beam oscillograph. The signal from the photocell, which recorded the lamp emission in the region $\lambda \approx 2500—3000$ Å, was applied to the second beam of the oscillograph. The laser emission threshold (the threshold electric energy of the lamp) was determined visually by means of a flash phosphor. The laser pulse energy was measured with a calorimeter.

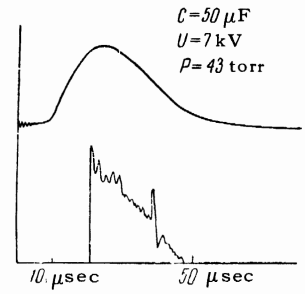

FIG. 1

A typical oscillogram for CF_3I is shown in Fig. 1. The duration of the excitation pulse was $\approx 40\ \mu$sec and that of the laser pulse $\approx 20\ \mu$sec. The laser pulse exhibited pulsation, i.e. "peaks" of $\approx 1—2\ \mu$sec duration. It should be mentioned that in our experiments the decay time of the laser pulse was longer than that in the work of Kasper and Pimentel, and that the front of the laser pulse did not always have an intense sharp peak, associated with the beginning of laser emission, such as was reported by Kasper and Pimentel. [6]

We investigated the dependence of the output energy in the laser pulse on the pressure in the working substance at various pump energies (Fig. 2). It is evident from Fig. 2 that, in a certain range of pressures, the output power has a maximum. In the case of CF_3I, this region lies at 80—100 torr. In this range of pressures, the laser pulse energy in CF_3I is $\approx 10^{-2}$ J for a pump energy $E_{el} = 1600$ J, and the peak value of the laser power is ≈ 1 kW. The laser emission threshold for this

[1)]Walter and Garrett[2] and Gould [3] used practically the same substances but they did not obtain population inversion.

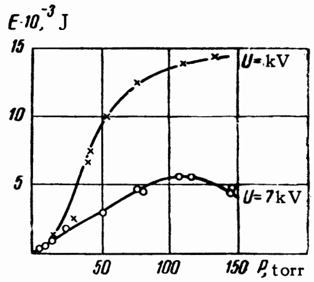

FIG. 2

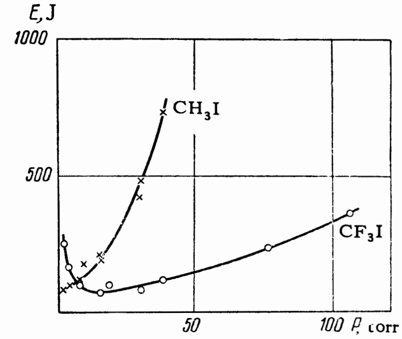

FIG. 3

substance is, under these conditions, 220 J at P = 27 torr. The output energy in the laser pulse is a linear function of the electrical pump energy over quite a wide range: from the threshold energy to 1600 J.

Further experiments were carried out with an elliptic light source, dielectric-coated mirrors; the laser tube and the lamp were both 250 mm long (working length). Under these conditions, the laser emission threshold was reduced severalfold. Figure 3 shows the curves which give the dependence of the laser emission threshold on the CH_3I and CF_3I pressures. From these curves, it is evident that the value of the threshold was minimal for CF_3I in the pressure range 10—20 torr and amounted to ≈ 80 J. In the case of CH_3I, the range of pressures where the threshold was minimal occurred at lower values of P and it was not determined exactly, but we found that it occurred at pressures lower than 1 torr. To obtain the maximum output power in the laser pulse, it is necessary to work at higher pressures (≈ 50—100 torr) and, therefore, the use of CF_3I was more promising than CH_3I.

The values of the laser emission threshold depended also on the operating conditions of the pump tube, which were varied by altering the capacitance of the capacitor. Thus, in the case of CH_3I, the values of 20, 25, and 120 J were obtained for the threshold for three values of the capacitance, 1, 4, and 50 μF, respectively at the same working gas pressure.

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