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Fig. 1

Figure 1: Fig. 1

**Abstract****Full Text****PHYSICS****V. K. KONYUKHOV, L. A. KULEVSKII, Corresponding Member  
of the Academy of Sciences of the USSR****A. M. PROKHOROV****STUDY OF AN OPTICAL RUBY GENERATOR AT LIQUID-NITROGEN TEMPERATURE**

In this work the characteristics of the spectral components of the radiation from a ruby laser operating at  $T = 77.4^\circ\text{K}$  have been obtained. At nitrogen <sup>(1)</sup> and helium <sup>(2)</sup> temperatures the spectrum of an optical ruby generator consists of two components. These components correspond to transitions from the metastable level  $\bar{E}(^2E)$  to the sublevels  $\pm^1/2$  and  $\pm^3/2$  of the ground state  $^4A_2$  (see Fig. 1).

For the experiments a specimen of light-pink laser ruby, 6 mm in diameter and 60 mm long, was selected. One of the end faces had a reflecting silver coating; through the other, unsilvered end face, the radiation emerged. The beam of light from the generator entered a Fabry–Perot interferometer with an air-gap thickness of 0.20 cm. Behind the interferometer there was a long-focus camera,  $F = 800$  mm, in the focal plane of which there was either a photographic plate sensitive to red light or a corresponding mask that made it possible to separate the light of the two components and feed it to two independent photomultipliers. The signals from the photomultipliers were recorded with a dual-beam oscilloscope.

Near the generation threshold the laser beam contained only one short-wavelength component, corresponding to the transition to the sublevel  $\pm^3/2$ . When the pumping energy was increased, a second, long-wavelength component appeared as well (see Fig. 2). By processing the interferogram, one can find the difference of the frequencies of the two components,  $(0.36 \pm 0.03) \text{ cm}^{-1}$ , which, within the limits of error, coincides with the splitting of the ground state of the  $\text{Cr}^{3+}$  ion in the  $\text{Al}_2\text{O}_3$  lattice, as determined by the method of paramagnetic resonance <sup>(3)</sup>.

**Fig. 1**

Fig. 2

Figure 2: Fig. 2

Fig. 3. Ratio of the energy  $E_{R_1}(^{1/2})$  of the long-wavelength component to the energy  $E_{R_1}(^{3/2})$  of the short-wavelength component as a function of the total generation energy  $E_{R_1} = E_{R_1}(^{1/2}) + E_{R_1}(^{3/2})$ .

Figure 3: Fig. 3. Ratio of the energy  $E_{R_1}(^{1/2})$  of the long-wavelength component to the energy  $E_{R_1}(^{3/2})$  of the short-wavelength component as a function of the total generation energy  $E_{R_1} = E_{R_1}(^{1/2}) + E_{R_1}(^{3/2})$ .

**Fig. 2.** Interferograms of the laser radiation of ruby at  $T = 77.4^\circ\text{K}$ , obtained with a Fabry–Perot interferometer with an air-gap thickness  $t = 2.0$  mm: on the left—near the generation threshold; on the right—at twice the threshold.

It further turned out that each of the components carries different amounts of energy per flash. The contributions of the two components depend on the total energy of generation. Near threshold the principal amount of energy is supplied by the short-wavelength component. However, sufficiently far above threshold the fraction of the ener-

of the long-wavelength component reaches  $0.21 \pm 0.01$  of the energy of the short-wavelength component and no longer depends on the total generation energy (see Fig. 3). The time behavior of the components proved to be sharply different. The component

**Fig. 3.** Ratio of the energy  $E_{R_1}(^{1/2})$  of the long-wavelength component to the energy  $E_{R_1}(^{3/2})$  of the short-wavelength component as a function of the total generation energy

$$E_{R_1} = E_{R_1}(^{1/2}) + E_{R_1}(^{3/2}).$$

with transition to the  $\pm^{3/2}$  sublevel is generated over  $0.5\text{--}0.8 \mu\text{sec}$ , and the greater the pump energy, the longer the generation lasts. The component with transition to the  $\pm^{1/2}$  sublevel is generated over  $0.15\text{--}0.1 \mu\text{sec}$ , and its

**Fig. 4.** Oscillograms of the temporal course of generation of the separated components: *a*—near the generation threshold, *b*—at twice the threshold excess. The upper beam corresponds to the short-wavelength component; the signal amplitude increases from top to bottom. The lower beam corresponds to the long-wavelength component; the signal amplitude increases from bottom to top. Time runs from left to right; one large scale division is equal to  $100 \mu\text{sec}$ .

generation time decreases with increasing pump energy. Oscillograms of both components are shown in Fig. 4.

Fig. 4. Oscillograms of the temporal course of generation of the separated components: a—near the generation threshold, b—at twice the threshold excess. The upper beam corresponds to the short-wavelength component; the signal amplitude increases from top to bottom. The lower beam corresponds to the long-wavelength component; the signal amplitude increases from bottom to top. Time runs from left to right; one large scale division is equal to 100  $\mu$ sec.

Figure 4: Fig. 4. Oscillograms of the temporal course of generation of the separated components: a—near the generation threshold, b—at twice the threshold excess. The upper beam corresponds to the short-wavelength component; the signal amplitude increases from top to bottom. The lower beam corresponds to the long-wavelength component; the signal amplitude increases from bottom to top. Time runs from left to right; one large scale division is equal to 100  $\mu$ sec.

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