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Figure 1 schematic

Figure 1: Figure 1 schematic

Abstract

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GENERATION OF THE RUBY R_2 LINE IN A DISPERSION RESONATOR

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Existing optical quantum generators usually have only a single operating wavelength, which is a great inconvenience, especially in physical investigations. Therefore, although at present intense coherent beams have been obtained in various OQG models over a fairly broad spectral interval from 0.3 to $3\,\mu$ ([1]), in studying the action of these radiations it is necessary to select the object of investigation to match the available OQG, and not the other way around, as would be desirable. In this connection, the problem of tuning the operating wavelength of an OQG is of current importance. In the case where the luminescence spectrum of the active body of an OQG contains several bands corresponding to different electronic transitions, for each of which, under appropriate pumping, negative absorption can be achieved, generation, as a rule, arises only on one of them, the one having the lowest threshold. To obtain generation on any luminescence band and to tune the operating wavelength of an OQG, we proposed using dispersing systems placed in the resonator ([2,3]).

Fig. 1. P –ruby rod, Π –dispersion prism, K –end mirror of the resonator

Figure 1 shows a schematic diagram of a dispersion prismatic OQG resonator. For each position of the rotating prism Π there is only one definite wavelength for which the light beam that has passed through the prism is perpendicular to the surface of the end mirror K. Therefore, by rotating the prism (or the end mirror), one can make the resonator closed only at the wavelength of the desired luminescence band.

An investigation was carried out of the operation of a dispersion resonator with a ruby crystal as the active body. A rod 12 cm long and 0.8 cm in diameter was used. The dielectric mirrors had a reflection coefficient of about 99% in the interval from 800 to 1000 mμ. The dispersing system consisted of three consecutively arranged 58-degree prisms made of glass with refractive index 2.02. In this case the angle α (Fig. 1) was approximately 225°, and the total

Fig. 2

Figure 2: Fig. 2

dispersion was about 0.25 mμ per angular minute.

As is known ([4]), two lines are observed in the luminescence spectrum of ruby: R_1 at 694.3 mμ and R_2 at 692.9 mμ, corresponding to electronic transitions from two closely spaced excited levels of the chromium ion $\bar{E}$ and $2\bar{A}$ to the ground state. Under ordinary conditions, generation occurs only on the R_1 line, since approximately 1.15 times more excited ions are concentrated on the $\bar{E}$ level than on the higher level

2 Å. If, however, the losses at the wavelength corresponding to the R_1 line are artificially increased, then, with appropriate pumping, generation on the R_2 line is possible [4].

Figure 2 shows the dependence of the generation threshold in the dispersive optical quantum generator studied on detuning of the end mirror. The point $\varphi = 9'$ on the abscissa corresponds to the condition in which the beam with wavelength 694.3 mμ (R_1) is perpendicular to the mirror surface. The point $\varphi = 3'$ corresponds to the same conditions for $\lambda = 692.29$ mμ (R_2). Simultaneously with these measurements, spectrograms of the OQG radiation and the intensity distribution in the far field were obtained for those points of the threshold curve that are marked by the numbers $1 \div 5$. It was found that the radiation at points 1 and 2 consists of a single line with wavelength 692.9 mμ (R_2); at point 3 a doublet 694.3–692.9 mμ is observed; and at points 4 and 5 only the 694.3 mμ line (R_1) is generated. In parallel with the change in the spectral composition, the pattern of the intensity distribution in the far field also changes. At those points of the threshold curve for which the radiation contained two lines, there were also two groups of spots. Their displacement from the resonator axis is proportional to the inclination of the end mirror to the emitted beam of the given wavelength and agrees with the concepts of operation of a resonator with tilted mirrors.

Fig. 2

Thus, the dispersive resonator makes it possible to achieve ruby generation not only on the R_1 line, but also on the R_2 line. At certain angles of rotation of the mirror an unstable regime is observed: generation occurs either on one or simultaneously on both luminescence lines. Further investigations should determine the nature of this instability for the specific case of closely spaced energy levels.

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Note: Figure translations are in progress. See original paper for figures.