A simple dye laser for demonstrations

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A simple scheme is described for demonstrating laser generation of ($\lambda = 570$ nm) in an ethanol solution of rhodamin 6G excited by a small N_2 laser LGI-21 ($P = 3$kW, $\lambda = 337$ nm). The solution is placed into a cell of 4–5 mm thickness with a silver or aluminum mirror and a quartz window at the ends. Excitation is produced by a beam focused by a spherical lens through the quartz window. Radiation from the dye laser leaves the cell at a small angle in the direction opposite to the exciting beam through the same lens and this produces collimated radiation which is then aimed in the desired direction by deflecting mirrors.

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Fast growth of laser technology stimulates development of new lecture demonstrations. Lasers using solutions of organic dyes which generate radiation in ultraviolet and infrared regions and allow tuning of the frequency of radiation over a wide range are of great interest. At present pulsed and continuous generators using a large number of dyes with optical pumping by lasers and gas discharge lamps have been constructed.[1,2] The pulsed molecular nitrogen gas laser is a good source of pumping for many dyes. Usually N_2 lasers with pulse power $P > 10$ kW are used. Rhodamin 6G is a classical dye in which it is easy to obtain generation.

In the present work the simple scheme (Fig. 1) used at the Optics Department of Khar'kov University for obtaining laser radiation in a solution of rhodamin 6G is described. An inexpensive, reliable, commercially available small N_2 laser LGI-21 ($P \approx 3$ kW, $\lambda = 337$ nm) is used as a source of excitation.

The power density of radiation of LGI-21 in a parallel beam with a diameter of ~3 mm was not sufficient to excite generation in a solution of rhodamin 6G placed into a simple resonator. To obtain generation it was necessary to concentrate the pumping radiation into a small volume of the solution by a spherical quartz lense L with a focal length of several centimeters. The solution of rhodamin in hydrolytic ethanol with a concentration of ~0.5 g/1 is contained in the cell C (of the type usually supplied with quartz spectrophotometers) with a thickness of 4–5 mm. On one side of the cell a nontransparent silver or aluminum mirror M is placed and on the other side a quartz window W through which the exciting beam 1 is focused into the solution. Laser radiation in rhodamin (beam 2, $\lambda \approx 570$ nm) is easily excited in the direction opposite to the exciting beam at any power and repetition rate of pumping pulses within the range of tuning of LGI-21. The brightest and visually perceived as continuous radiation is achieved at the maximum pumping power with a repetition rate of 50 Hz. In spite of the small volume of the excited dye the intensity of generated radiation is high (a thin absorbing film can be evaporated by the focused beam) due to high efficiency of generation in rhodamin excited by a N_2-laser.

For separation of generated (2) and exciting (1) radiation the cell is placed at a small angle to the exciting beam. The divergence of the radiation coming out of the cell is large due to the low quality of the resonator (the mirror M and the quartz window W) and nonuniformity of excitation by a focused beam. Therefore, in order to obtain a well collimated beam for demonstration in a large auditorium the beam is sent through the lense (L) producing this collimation and reflected out of the scheme by deflecting mirrors (M_d).

The general view of the working installation is shown in the photograph (Fig. 2). The trace of the generated beam is easily seen due to the photograph being made in a dispersive medium. The exciting beam is barely observed visually due to weak fluorescence of the scattering particles but on the photograph it is well seen because of the sensitivity of the film to the scattered UV radiation. At the same time it is practically invisible after reflection from the quartz window of the cell as the reflection coefficient of the quartz window is small. Coherence of the radiation generated in the rhodamin can be checked by interference or diffraction experi-

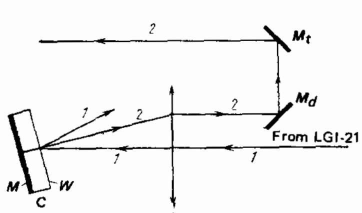

FIG. 1.

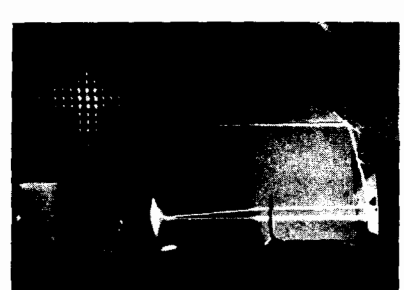

FIG. 2.

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ments. On the upper left of the photograph the diffraction pattern formed by the beam passing through an object grid with small (~10 μm) square openings used in electron microscopes is shown.

The scheme proposed can be easily aligned and for alignment and demonstration its elements can be assembled on any supports mounted in any simple manner. If no quartz lenses or windows are available they can be substituted by glass components. Ordinary household mirrors can be used as mirrors M and M_4. However, when such components are used the intensity of generated radiation is reduced due to attenuation of exciting radiation in glass. The time of continuous operation of the laser with a single injection of rhodamin into the cell is practically unlimited. In our laboratory such a laser was operated continuously during 1–2 hours and it can be used many times if the cell is well sealed to prevent evaporation of ethanol.

Therefore, the principle of generation of laser radiation in organic dyes with laser excitation can be easily demonstrated with the help of the described installation, and the intense coherent radiation in the green-yellow part of the spectrum can be used in many experiments with laser beams.

[1]Dye Lasers. Ed. F. P. Schafer, New York, Springer-Verlag, 1973 (Russ. Transl., Mir, M. 1976).
[2]Spravochnik po Lazeram (Laser Handbook), ed. A. M. Prokhorov, Vol. 1, Sov. Radio, M. 1978.

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