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Publication Date

1975-03-01

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March 1975

Prepared for the U. S. Atomic Energy Commission
under Contract W-7405-ENG-48

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LBL-3765
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Submitted to Optics Communications

LBL-3765
Preprint

UNIVERSITY OF CALIFORNIA

Lawrence Berkeley Laboratory
Berkeley, California

AEC Contract No. W-7405-eng-48

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MARCH 1975

Simultaneous Two Wavelength Output of an N_2 Pumped Dye Laser

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ABSTRACT

A simple method for generating a dual wavelength output of an N_2 laser pumped dye laser is described. A wedge placed in front of the tuning grating intersects only part of the cross section of the light beam. Therefore, feedback is provided for two different wavelengths simultaneously.

For a number of applications, like difference frequency generation, two-photon spectroscopy, excited state spectroscopy, two tunable lasers are required. In case both wavelengths are obtainable from the same lasing dye a number of systems have been developed to generate two frequencies in one laser [1-6]. We want to present a new method, which is extremely simple and easy to operate.

Figure 1 shows the setup used. The N_2 laser-pumped dye laser is of the usual design, consisting of a partial mirror, a transversely pumped dye cell, a telescope, and a grating [7]. We now place a rectangular glass wedge between the beam expanding telescope and the grating in such a way, that it intersects only the lower half of the beam. The angle of incidence is then different for the upper and lower half of the grating and the dye laser can operate on two wavelengths simultaneously. Note that the wedge divides the beam along a line normal to the ruling of the grating. Therefore, the laser line width should remain unchanged with the insertion of the wedge. Since a wedge (or prism) has its angle of reflection depend on the angle of incidence, this provides a means to tune the lasing frequency of the lower half beam with respect to the upper half of the beam.

The deflection of a prism can be written as (8):

$$\delta = \alpha + \arcsin [\sin \epsilon \sqrt{n^2 - \sin^2 \alpha} - \cos \epsilon \sin \alpha] - \epsilon$$

whose α is the angle of incident, ϵ the apex of the prism and n the refractive index. Its minimum deflection is

$$\delta_{\min} = 2 \arcsin \left(n \sin \frac{\epsilon}{2} \right) - \epsilon.$$

For a given ϵ the maximum deflection depends mainly on how large one can make α . Reflection losses and size considerations make it impractical to go much above 75° . The choice of n is of minor importance.

The angular dispersion of a diffraction grating in Littrow mount is given by [8] as:

$$\frac{d\phi}{d\lambda} = 2 \cdot \tan\phi / \lambda$$

where ϕ is the angle of incidence. With the blaze angle of the grating we used ($61^\circ 10'$) and $\lambda = 4700\text{\AA}$. The value for $\frac{d\phi}{d\lambda}$ is $0.45 \left(\frac{\text{mrad}}{\text{\AA}} \right)$.

With this dispersion and an $\alpha_{\max} = 75^\circ$ one obtains a tuning range for the wavelength difference of the two beams from $50\text{\AA}$ to $246\text{\AA}$ with a wedge of 3 degrees (52 mrad). For a wedge of 8 mrad, the tuning range is $8\text{\AA}$ to $50\text{\AA}$.

To verify these considerations, we inserted a wedge of optically polished glass ($n = 1.55$) into the laser cavity. Its dimensions were about $1'' \times 2''$; the wedge angle was 3 degrees. For tuning, the wedge was rotated around a vertical axis (labeled z in Fig. 1). As the vertical adjustment of the grating has to be better than 0.05 mrad, care has been taken to have no vertical wedge component. This was facilitated by rotational fine adjustment around the x -axis.

Simultaneous lasing at two wavelengths was easily obtained. The relation intensities of the two outputs could be changed by adjusting the position of the wedge in the z -direction. The tuning behavior

corresponded to the values given above.

In this setup, the polarizations of the two beams are the same. However, a variation of this method can provide orthogonal polarizations. A wedge of birefringent material with its optical axis parallel to the direction of the wedge intersects the whole beam cross section. The o- and e-ray, passing through the wedge, are deflected differently and therefore generate two orthogonally polarized outputs of different wavelengths. The relative intensities can be adjusted by a polarizer placed between dye cell and telescope.

ACKNOWLEDGEMENTS

I want to thank Professor Y. R. Shen for a critical reading of the manuscript.

This work was supported by the U.S. Energy Research and Development Administration.

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FIGURE CAPTION

Fig. 1. Schematic diagram of the setup.

XBL 753-5998

Fig. 1

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