CLM-P 391

QUENCHING OF LASER ACTION IN CRESYL VIOLET BY 6943 Å RADIATION

D E Evans, J Purić* and M L Yeoman†

(To be submitted to Applied Physics Letters)

ABSTRACT

Experiments demonstrate complete quenching of laser action in cresyl violet dye pumped by the second harmonic of a ruby laser, in the presence of 6943 Å light. The mechanism responsible may be depletion by stimulated emission of the population in the upper laser level.

*IAEA Fellow attached from Institute of Physics, Belgrade, Yugoslavia

†Royal Holloway College (University of London) Egham, Surrey, UK

UKAEA Research Group
Culham Laboratory
Abingdon
Berks

23 April 1974
dg

It is well known that cresyl violet dye supports laser action in the wavelength range 6460 Å to 7000 Å (1,2). However, population inversion is difficult to achieve in this material and optical filtering procedures designed to lower the laser threshold have been described (3). It has also become usual to mix cresyl violet with rhodamine 6G, whose role is to transfer excitation from the pumping light to the cresyl violet. But the maximum power realised in flashlamp-pumped mixtures of this kind is typically a few times less than that generated in rhodamine 6G alone (4).

In this letter, we describe the influence of light at 6943 Å on the performance of a pulsed dye laser pumped by the second harmonic of the radiation from a ruby laser. The arrangement of the apparatus, in which the pump light irradiates the dye cell from a direction transverse to the axis of the optical cavity formed by two dielectric mirrors, is similar to that of Bradley et al (5). Passage of the 90 MW pulse from the ruby laser through the ADP crystal generates 21 MW of second harmonic in the UV at 3471 Å and leaves a residual 48 MW of red light at 6943 Å . A vessel with quartz windows, located between the frequency-doubling crystal and the dye cell, could be filled with a solution of $CoCl_2$ in ethanol which served to reduce or remove the light at 6943 Å , at the same time attenuating the UV second harmonic at 3471 Å , but less severely.

The UV radiation, with and without the residual red light, irradiated three different dye preparations, and the intensities of the resulting dye laser pulses were measured by means of a vacuum photodiode. The dye solutions were (1) rhodamine 6G: 0.5 millimolar solution in ethanol (2) cresyl violet: 0.3 millimolar solution in ethanol, and (3) rhodamine 6G: 1 millimolar solution, plus cresyl violet, 0.3 millimolar solution, in ethanol.

In the case of rhodamine alone, the presence of red light reduced the laser output to 65% of the value measured when the red light was excluded. Laser action was detected when the second harmonic pumped the cresyl violet solution, but the pulse was 7×10^{-4} times as intense as that observed in

rhodamine. Red light added to the second harmonic quenched laser action completely in cresyl violet. On the other hand, the mixture of rhodamine and cresyl violet produced a pulse 25% more intense than that generated by rhodamine 6G alone, when pumped with UV light. Once again, the addition of red light to the pump inhibited laser action in the dye mixture altogether. In every case that a dye laser pulse was observed, its polarization was found to be almost parallel to the polarization of the second harmonic pump light. These observations are summarized in Table 1.

The capacity of 6943 Å light to quench laser action in cresyl violet was investigated in a more quantitative way by varying the amount of $CoCl_2$ in the filter over the range 1.07×10^{-1} to 6.6×10^{-3} molar concentration. The transmission of the filter cell at each concentration was measured at 3471 Å and at 6943 Å (when transmission at the latter wavelength could be detected). The three dye solutions described above were studied, and the resulting dye laser pulse intensity, expressed as a fraction of the maximum intensity observed for each dye solution, is plotted in Figure 1 as a function of the cell's transmission at 3471 Å .

In every case, the dye laser performance improves as the transmission at 3471 Å increases, reaching a peak at about 65% transmission, when the corresponding transmission at 6943 Å has reached 0.1% . As the filter transmission is increased further, performance falls off owing to the dominance of the ruby red radiation.

The quenching of dye laser output by residual red light has been observed previously, for example in rhodamine B by Nagata and Nakaya (6), who attribute the phenomenon to a loss of population in the first excited singlet state S_1 , caused by photo-excitation from S_1 to the second excited singlet level S_2 . However, Lin and Dienes (7) have recently made a direct measurement of the rate of radiationless internal conversion from S_2 to S_1 in cresyl violet solutions, which they find to have a time constant of 30 picoseconds. In view of

our observed pulse duration of 25 nanosecond, this very fast internal conversion rate appears to preclude photo-excitation to the second singlet level as a possible quenching mechanism in cresyl violet.

Lin and Dienes (8) have also observed amplification of a probe beam of 6943 Å radiation when the latter passed through an optically pumped solution of cresyl violet in methanol. We accordingly suggest that the quenching mechanism may be the depopulation of the S_1 state by stimulated emission of radiation induced by the 6943 Å light. A measurement now in progress of the intensity of the 6943 Å residual light before and beyond the dye cell should determine whether stimulated emission or photo-excitation is the mechanism responsible for the inhibition of laser action in cresyl violet solutions by residual ruby red light.

It is worth observing that the comparatively unsatisfactory performance of flash-pumped cresyl violet rhodamine 6G lasers may stem from the quenching action of a red component in the pump light.

PUMP LIGHT	DYE SOLUTIONS IN ETHANOL		
	RHODAMINE 6G 0.5×10^{-3} M	CRESYL VIOLET 0.3×10^{-3} M	RHODAMINE 6G + CRESYL VIOLET 1×10^{-3} M + 0.3×10^{-3} M
3471 Å	I (0.95)	7×10^{-4} I(0.95)	1.28 I (0.97)
3471 Å + 6943 Å	0.65 I(0.92)	0	0

TABLE 1

The intensities of dye laser pulses quoted relative to that observed in rhodamine 6G pumped by 3471 Å (I). Numbers in brackets are polarization $\frac{I_{\parallel} - I_{\perp}}{I_{\parallel} + I_{\perp}}$ of the dye laser relative to that of the second harmonic pump light.

REFERENCES

1. K H Drexhage, Laser Focus. 9, 35 (1973).

2. C E Moeller, C M Verber and A H Adelman, App.Phys.Letts. 18, 278 (1971)

3. P Gacoin and P Flamant, Optics Comm. 5, 351 (1972).

4. P Dawson - Private communication 1974.

5. D J Bradley, J V Nicholas and J R D Shaw, App.Phys.Letts. 19, 172 (1971).

6. I Nagata and T Nakaya, J.Phys.D. Appl.Phys. 6, 1870 (1973).

7. C Lin and A Dienes, J.Appl.Phys. 44, 5050 (1973).

8. C Lin and A Dienes, Optics Comm. 9, 21 (1973).

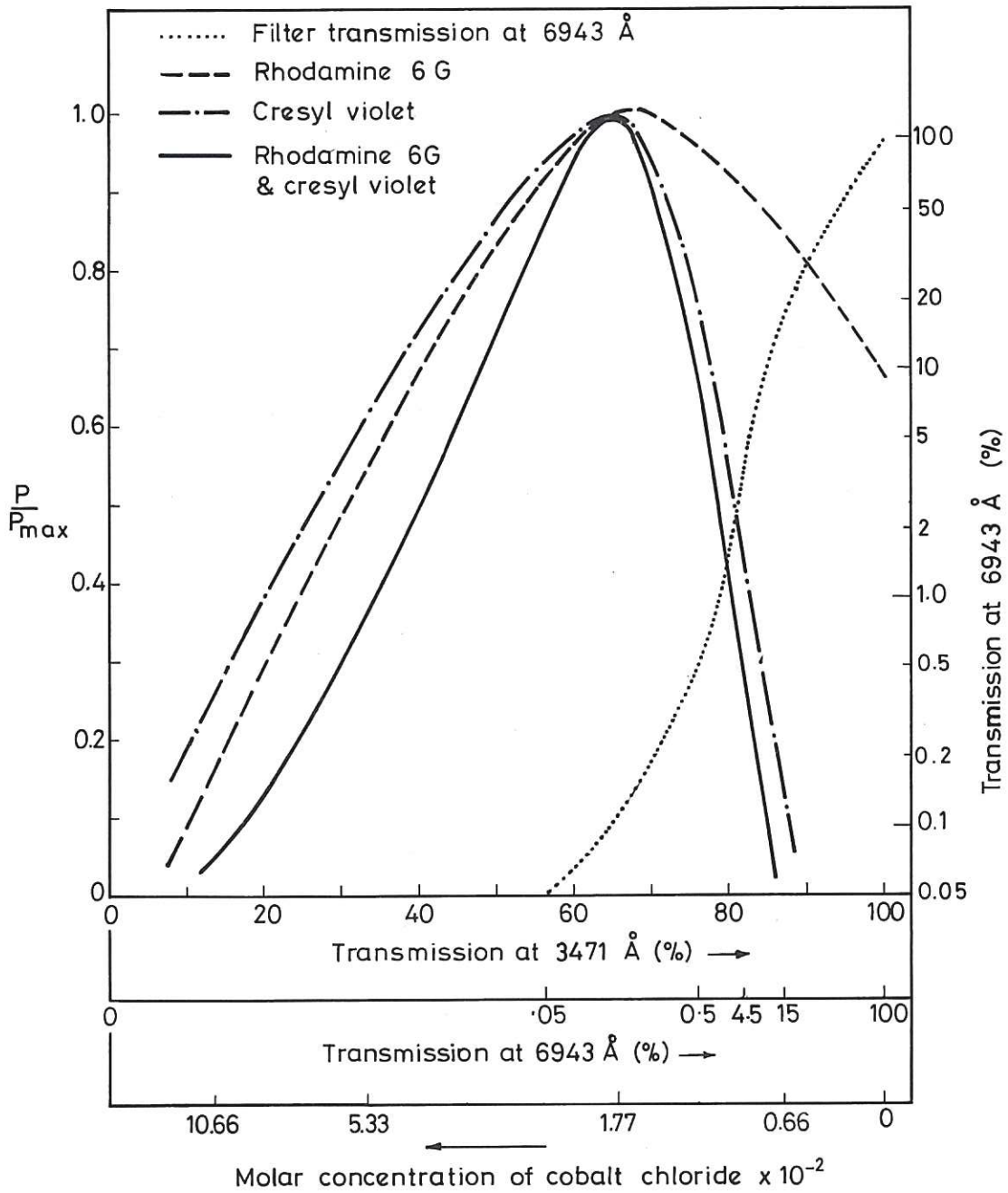

Fig. 1

Output power of stimulated emission normalised to peak power, as a function of filter transmittance at 3471 Å Representative values of transmittance at 6943 Å and cobalt chloride concentration are included along the abscissae.

CLM - P 391