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High power CW dye laser emission around 888 nm

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Résumé. — Nous rapportons ici l'observation d'une puissance de 1,5 W à 888 nm émise par un laser à colorant HITC pompé par un laser à Kr^+ émettant 7 W sur ses raies rouges. La bande d'accord en longueur d'onde est comprise entre 825 et 980 nm : la limite supérieure est de 40 nm supérieure à celle publiée antérieurement. Une bonne stabilité dans le temps de la solution de colorant a été observée sur des mois de fonctionnement à pleine puissance.

Abstract. — We report a maximum output power of 1.5 W at 888 nm from a HITC jet stream dye laser pumped by a Kr^+ laser emitting 7 W on its red lines. The observed tuning range is 825-980 nm : the long wavelength limit is 40 nm above previously reported results. Good stability of the dye solution is observed over months of operation at full power.

CW tunable laser emission can now be accomplished throughout the near UV, the visible and the near IR using various classes of dyes and/or colour centres in crystals. CW laser emission near 900 nm has previously been reported in two cyanine dyes : HITC [1, 2] and IR 140 [3]. More recently colour centre lasers using F_2^+ centres in LiF showed high laser efficiency in the same wavelength range [4, 5]. For application to ^3He optical pumping, our « tandem pumping » scheme requires over one watt of tunable laser light near 890 nm with good long term stability. With this goal in mind we have reinvestigated the properties of the HITC jet stream dye laser.

We used a krypton ion laser (CR 3000K) as a pump source providing 7 W multiline output power at 647 and 676 nm. The jet stream dye laser (CR 599-01) had a folded cavity, with a folding mirror of $R = 50$ mm radius. The output mirror reflectance ranged between 0.94 and 0.99 within the 825-970 nm region. Tuning was achieved with a three plate Lyot filter. The HITC dye (1,3,3,1',3',3', hexamethyl 1-2,2' indotricarbocyanine perchlorate) was purchased from a Japanese firm ⁽¹⁾ where it is referred to as NK 2421. The optimized concentration of the dye was (0.9 ± 0.1) g/liter ($\sim 1.7 \times 10^{-3}$ mol/liter). As a solvent we used ethylene glycol and DMSO in a ratio 1 : 3. No efficiency additive was used.

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In order to avoid saturation of the dye emission at high pump power we replaced the pump of the commercial dye circulation unit by a more powerful one. This required a careful selection of the jet nozzle so as not to induce turbulences spoiling the jet optical quality. In practice we could speed up the jet up to 12 m/s, which allowed the reported results of figure 1

Fig. 1. — Output power of an HITC dye laser versus pump power from the Kr^+ laser. The solid line refers to pumping with the red lines of the Kr^+ ($\lambda = 647$ and 676 nm), the dashed line to pumping with the IR lines ($\lambda = 752$ and 799 nm). No tuning element was inserted in the cavity and the wavelength was $\lambda = 888$ nm.

(solid curve) : we observed a linear increase of the output power as a function of the red pump power up to 7 W. To avoid saturation at high power the pump beam had to be slightly defocussed on the jet. No attempt was made to reach low threshold by using the « tight focussing » cavity configuration and the results of figure 1 were recorded with a spherical $R = 50$ mm pump mirror. However in other conditions thresholds as low as 200 mW were measured. Figure 2 shows the tuning curve of HITC at 6.6 W of red pump light. As compared to previously reported results [2], the lower limit of the tuning range is the same but the upper limit is higher by 40 nm. Over three months of operation at full power the decrease of the output power was less than 10%.

The slope efficiency of the solid curve in figure 1 is 23%, more than twice as much as previously reported in [2]. For comparison we plotted in the same figure our results for pumping HITC with the IR lines of the Kr^+ laser at 752 nm and 799 nm (dashed curve in figure 1), recorded with a 10 times more dilute dye solution : the slopes of both the solid and the dashed curves are about the same, indicating that the laser efficiency of the dye does not critically depend on the pump wavelength, provided it ranges within the absorption band (for HITC the absorption band peaks at 744 nm). Since more power is available in the red, it seems to be more favourable to pump HITC with the red lines of the Kr^+ laser than with the IR ones.

The maximum output power recorded with HITC

Fig. 2. — Output power versus wavelength for HITC. The pump power is 6.6 W (red lines at 647 and 676 nm of the Kr^+ laser).

(~ 1.5 W) is similar to the power delivered by $\text{LiF} : \text{F}_2^+$ colour centre lasers (1.7 W is reported in [6]). The F_2^+ lasers have a higher efficiency than the IR dyes ($\sim 50\%$); however, presently, they require a more sophisticated technology than dye lasers and, according to our own experience and also to reference [5], they show severe fading problems of the crystals with irradiation. This makes the IR dye lasers still attractive tools for many applications where both high tunable power and long term stability are required.

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