Self-frequency tuning in birefringent KNM laser crystal

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Intracavity frequency tuning has been demonstrated in many laser systems by using tilted birefringent plates which allow narrow band selection [1]. In most common devices the resonator contains at least two pairs of surfaces oriented at Brewster's angle, those of the laser medium and the ones of the birefringent plate. In this cavity, the wavelength selection is achieved by rotating the birefringent plate in its own plane. However, the theoretical treatment of such devices, in relation with its bandwidth (FWHM for full width at half maximium) and working range (FSR for free spectral range), has been rarely worked out. Moreover, as far as we know, frequency tuning obtained by the laser medium itself has not been treated. The reason could be that only a few laser media are made from anisotropic crystals, and even in this case, only a few of them (mainly highly concentrated or stoichiometric laser crystals) can be used as birefringent gain plates in micro-laser cavities. On the other hand, frequency tuning in a birefringent gain crystal by self-birefringence filtering would be of interest only in broadband emitting lasers.

In this paper we report an experimental demonstration of broadband wavelength self-tuning in $K_5Nd(MoO_4)_4$ laser crystal (KNM) together with a theoretical treatment of the operation of the device based on its birefringence properties.

In a previous work [2] laser experiments were performed with an a-cut KNM crystal plate by using a longitudinal pumping scheme with a tunable pulsed Ti:shappire laser (9 ns pulsewidth and about 30 mJ energy). The resonator was a 15 cm long symmetric confocal one, with high reflectivity coated mirrors. When the a-plate was placed perpendicularly to the resonator axis (with no polarization selectivity) the spectrum of the laser emission was confined within the 1063.5-1069.5 nm region with its polarization almost perpendicular to the optical axis.

The self-frequency tuning in KNM was obtained by inserting an a-cut plate, 2.150 mm thick, inside the resonator at Brewster's angle. The crystal was placed in a holder which allowed the rotation of the plate in its own plane. The wavelength selection occurs due to the different retardations for the laser field components along the two principal directions defined by the birefringent crystal. At a given position of the crystal plate, when the wavelength of the oscillating mode corresponds to an integral number of full-wave retardation in the plate, the laser operates in the *p* polarization of the Brewster surface with no losses. At any other wavelength the losses at the Brewster surfaces are high enough to impede the mode oscillation after a few round trips. Figure 1 shows the experimental self-frequency tuning along the FRS of the KNM crystal obtained by rotating the birefringent gain plate in its own plane. The shortest wavelength laser peak corresponds to an orientation of the plate in which the projection of the *c*-axis onto the plane perpendicular to the laser beam forms an angle of 44º with the Brewster's polarization direction. The remaining spectra were obtained by rotating the plate in steps of 0.143º.

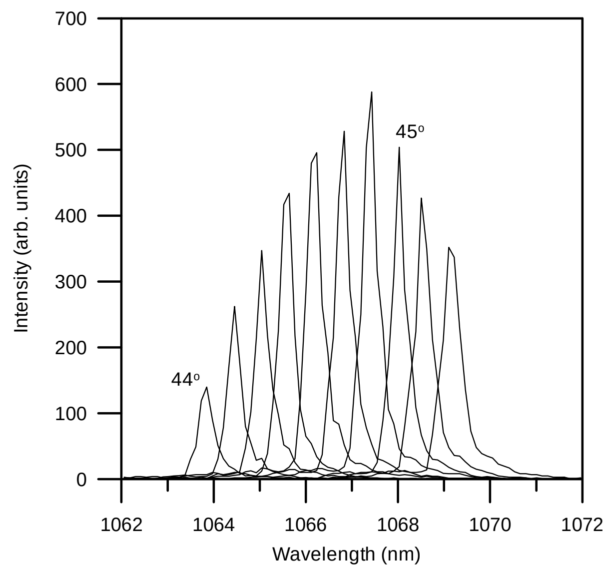

Figure 1.- Self-frequency tuning in KNM crystal.

In order to investigate the tuning characteristics of the spectral filter, induced by the crystal birefringence, we have calculated the eigenvalues of the Jones matrix [3] that describes the system (passive birefringent Brewster plate) and gives its transmittance, defined as the flux remaining in the resonator after *n*-round trips through the crystal plate. The finesse of the self-birefringent filter, defined as the ratio between the SFR of the laser and the FWHM of the laser pulse, is 20. In our case, this number could be even much higher due to the limited resolution (around 0.3 nm) of our detection system

As a conclusion, we have demonstrated a very simple and powerful method for wavelength-selective tuning in broadband emitting lasers based on the laser crystal own birefringence. As far as we know this is the first time the operation of such a device is demonstrated.

Acknowledgements

This work has been supported by the Spanish Government MCYT (Ref.: MAT2000-1135 and BFM2000-0352), and the Basque Country University (Ref.: UPV13525/2001).

References

[1] J.M. Yarborough and J. Hobart, post-deadline paper at CLEO Meeting (May 1973).

[2] I. Iparraguirre, R. Balda, M. Voda, M. Al-Saleh, and J. Fernández, J. Opt. Soc. Am. B, **19**, (2002).

[3] R. C. Jones, J. Opt. Soc. Am. **31**, 448 (1941).