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# Suppression of mode-hopping in a single-frequency intracavity-frequency-doubled Nd:YAG ring Laser.

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## ABSTRACT

Suppression of mode-hopping in a high-power intracavity-frequency-doubled Nd:YAG ring laser has been observed allowing continuous tuning over ~80 axial mode spacing. An explanation for this behaviour is proposed.

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Mode-hopping is a typical, but undesirable feature of many lasers, being particularly noticeable and troublesome in lasers designed for single-frequency operation. It occurs as the result of small changes in cavity length, or shift (eg. due to temperature change ) of the gain peak. Elimination of mode hopping can add considerable complexity to a laser, as typical counter measures include active stabilization of the resonator length to a stable reference cavity, and temperature stabilisation of the gain medium.

In this paper we describe a mechanism by which mode-hopping can be suppressed in a single-frequency intracavity-frequency-doubled laser without the need for complex feedback stabilisation, and allowing continuous, i.e. mode-hop free tuning over many axial mode spacings. The explanation for this behaviour is based on the fact that adjacent (non-lasing) axial modes are further suppressed by an additional loss due to sum frequency generation, which is twice the loss due to second harmonic generation experienced by the lasing mode. In a low loss resonator with efficient intracavity-frequency-doubling this extra loss can outweigh the increase in gain accessed by adjacent modes as cavity length tuning brings them towards the peak in the gain cross-section. The result is that continuous tuning is possible over many axial mode spacings.

To investigate this effect further we have conducted experiments on an intracavity-frequency-doubled single-frequency Nd:YAG ring laser end-pumped by a 20W diode bar. A 'bow-tie' cavity design was used, similar to that described in [1], with a Brewster-angled LBO crystal for efficient frequency doubling to 532nm. In addition, two prisms were inserted into the cavity, each with a Brewster angle surface, and a normal anti-reflection coated surface, so that by translating a prism parallel to its Brewster face, cavity length scanning could be made with minimal beam deviation.

Despite a non-optimised laser mode size in the LBO, the laser produced ~1.4W of single-frequency output in the green at 532nm. By scanning the cavity length we obtained continuous tuning of this single frequency output over a range of ~80GHz corresponding to ~80 fundamental axial mode spacings. This range is consistent with our expectations based on a simple model accounting for the effects of the nonlinear loss due to sum frequency generation. With further optimisation of the cavity design it should be possible to significantly extend the mode-hop-free tuning range.

### References

[1] K.I. Martin, W.A. Clarkson, D.C. Hanna "Stable, high-power, single frequency generation at 532nm from a diode-bar-pumped Nd:YAG ring laser with intracavity LBO frequency doubler", to be published.