Linewidth Measurement and Frequency Control of High Power, Single Frequency Diamond Raman Lasers

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In recent decades, the need for tunable, high power, narrow linewidth, single frequency lasers has grown substantially due to the rise of fields such as quantum computing, high resolution spectroscopy and more. Raman lasers have recently shown to be suitable for generating high power single longitudinal mode output from simple cavities due to the absence of spatial hole burning [1]. When using diamond as the Raman medium, up to 22W single frequency at 589nm has been achieved for standing-wave resonator with intracavity second harmonic generation. However, the theoretical and experimental details surrounding achievable linewidths have not been reported.

This work aims to experimentally measure the linewidth of a free running quasi-CW diamond Raman laser using heterodyne beat note analysis. In the experiment, we observed a chirp of the laser frequency (Figure 1 Right) attributed to thermal effects within the diamond, which fundamentally limited the resolution of the linewidth analysis. An optimized scanning Fourier transform technique was developed to derive the linewidth of the laser. This yielded a resolution-limited linewidth as low as 580 $\pm$ 150 kHz, representing an order of magnitude improvement in resolution compared to [2]. Through these findings, we also propose a novel thermo-optic laser stabilisation and tuning mechanism, with response speeds comparable to piezo-electric devices.

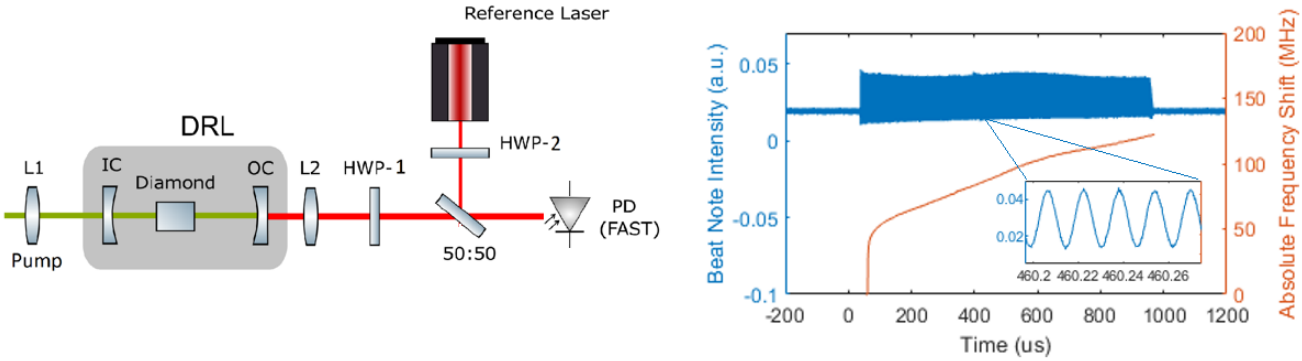

Figure 1: Left: Experimental setup. Right: Beat Profile with thermally induced frequency shift.

[1] O. Lux, S. Sarang, O. Kitzler, D. Spence, and R. Mildren, *Intrinsically stable high-power single longitudinal mode laser using spatial hole burning free gain,* Optica 3, 876-881 (2016).

[2] X. Yang, O. Kitzler, D. Spence, Z. Bai, Y. Feng, R. Mildren, *Diamond Sodium Guide Star Laser* (Optics Letters 45(7)) 2020.