L9 GENERATION OF TUNABLE INFRARED RADIATION BY STIMULATED RAMAN SCATTERING IN ALKALI VAPOURS

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Stimulated electronic Raman scattering in metal vapours [1] provides a simple way of converting the tunable visible output of a pulsed dye laser into a tunable infrared output [2,3]. Recent experimental results and their comparison with theoretical calculations will be presented.

Experimentally two types of dye laser have been used, either pumped by a N_2 laser or (for higher powers) pumped by the second harmonic of a ruby laser. Using the latter, Raman scattering on three transitions in caesium vapour have been observed. These are $6s \rightarrow 7s$, $6s \rightarrow 8s$ and $6s \rightarrow 9s$ and the tuning ranges achieved for the infrared Raman output on these transitions are 2.5–4.75 μm, 5.67–8.65 μm and 11.7–15 μm with generated powers of up to 25 kW, 7 kW and 2 kW respectively [4].

The Raman gain as a function of infrared wavelength (and hence also the expected infrared tuning range) can be easily calculated using tabulated oscillator strengths of alkali metals. The net gain is greatly reduced however by the large diffraction loss suffered by the generated infrared radiation [5]. The very considerable effects of this diffraction loss on calculated Raman threshold and tuning range will be discussed. For example it will be shown that an oscillator configuration for the Raman amplifier does not significantly reduce the Raman threshold unless diffraction loss can be drastically reduced by the use of a large area dye laser beam.

Contrary to expectations, the spectral width of the generated signal has been found to be 0.3–1.6 cm^{-1}, which is significantly broader than both the 0.1–0.2 cm^{-1} linewidth of the dye laser pump, and the ~0.03 cm^{-1} Doppler width of the Raman transition (at vapour pressures of ~10 torr). Preliminary observations indicate that the linewidth of the generated radiation increases with increasing dye laser intensity. Broadening of the spontaneous Raman linewidth will also have the serious effect of increasing the stimulated Raman threshold and thus reducing the available infrared tuning range. The measured thresholds are as much as two orders of magnitude greater than those which are predicted assuming a Doppler broadened transition, even when the effects of diffraction loss are included.

Techniques aimed at reducing the Raman linewidth are described. One of these uses a multiple pass configuration to allow a reduced pump intensity. Another approach involves injecting into the vapour cell the radiation from an external narrow linewidth infrared source. This radiation is then amplified by the stimulated Raman process.

References

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