THE ROLE OF DIFFRACTION IN ULTRA-BROADBAND LIGHT GENERATION

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In the field of multi-frequency laser physics, both theory and experiment indicate that Ultra-broadband Multi-frequency Raman Generation (UMRG) is unique in terms of the number of distinct frequencies of *comparable* energy that can be generated [1-7]. UMRG differs from conventional Raman conversion in that resonant and symmetric (two-colour) pumping is employed. Using H_2 gas, beams consisting of *tens* of frequencies are possible. Atmospheric UMRG has the potential for generating beams with around 150 frequency channels [5]. However, while experiments use finite-size pump beams, UMRG theory has to date relied on plane-wave analyses.

We report the first theoretical investigations of UMRG incorporating finite-beam effects in one and two transverse dimensions. The complexity of transverse UMRG can be gauged by considering finite pump beams and neglecting both diffraction and dispersion; UMRG itself leads to very significant transverse effects. For negligible dispersion, diffractive effects can actually increase bandwidth. However, finite dispersion and increasing levels of strong diffraction cause bandwidth to decrease monotonically (an important consideration for experiments employing tightly-focused input beams).

The full impact of transverse effects will be summarised in terms of key characteristics of the resulting multi-frequency beams including bandwidth, beam quality and the field distributions in the constituent frequency channels. Snapshots of the evolution of UMRG beams demonstrate that plane-wave analyses are clearly invalid. However, we find that bandwidths of similar magnitudes are still possible. Indeed, employing pump beams consisting of the 2nd harmonic of a Nd:YAG laser and a Raman sideband, the light generated spans across the visible spectrum and beyond when using either H_2 or air.

In the modelling of atmospheric UMRG, both self-phase and cross-phase modulation (SPM and XPM, respectively) are also taken into account. Due to the grating coefficients and the sheer size of the bandwidths generated, XPM tends to overwhelm SPM, leading to a radical departure from single-beam self-focusing. Nevertheless, our calculations show that even XPM is a relatively small effect when compared to the transverse Raman-dispersive phase imprint.

Plane-wave analyses predict that many *hundreds* of frequency channels may be filled when cooled (pure) N_2 is used. In view of the above findings, there is every reason to expect that comparable bandwidths may also be attained when fully two-dimensional pump beams are employed.

References

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