Higher Order Effects in Ultra-broadband Multi-frequency Raman Generation

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Introduction

Ultra-broadband Multi-frequency Raman Generation (UMRG) is one of the most novel nonlinear optical processes to have emerged over the last few years. With H₂ gas as the Raman medium, our analyses have predicted that nearly 50 distinct frequencies of comparable energy may be generated 1-4. More recent calculations for UMRG in air at atmospheric pressure, have predicted that beams containing around 150 waves may be attained 5. Experimental results, that support our overall predictions, are appearing in the literature. However, in some configurations, effects which are additional to the main UMRG process also come into play. We have investigated a range of such higher order effects and their implications for the efficiency of ultra-broadband light generation. We outline here results dealing with two particular higher order effects: competing nonlinear processes and detuning of the UMRG pumps from the Raman resonance of the medium.

Results

Our model equations have been generalized to incorporate a non-parametric competing signal and a quantitative study undertaken of its affect on the primary UMRG process. An effective gain-length product for the parasitic process, \( Z^{\text{eff}} \), was introduced and a simple analytical model developed for the case of competing processes arising from background noise or amplified spontaneous emission. Model predictions were found to be in good agreement with full numerical simulations, and showed that the efficiency and character of UMRG can be robust in this respect. UMRG can also be robust in this respect.

While we have shown that non-parametric competing effects need not present any problems, it is also plausible that frequencies of the UMRG spectrum could parametrically generate a parasitic wave. Our results on detuning effects have been used to assess this possibility and we found that UMRG can also be robust in this respect.

References

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