The Generation of Ultrabroad Bandwidth Light

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Stimulated Raman Scattering (SRS) is a fundamental nonlinear process. In many cases, a medium is pumped by intense light of, mainly, one frequency and SRS generates a "comb" of new frequencies. These new frequencies are each distanced from the pump frequency by an integer multiple of a fixed value - the Stokes shift. However, the frequency conversion of a significant amount of energy invariably results in having negligible energy at most of the other frequencies of the comb. Typically, most of the energy is converted from one freqency to another, or to a very small group of others, and is not distributed evenly throughout the comb. Remarkably, SRS with resonant symmetric pumping (two collinear input pulses with the same shape and separated in frequency by the Stokes shift) has only very recently been examined in detail [1,2]. Our modelling has predicted the generation of multifrequency beams consisting of nearly 50 waves of distinct frequency and comparable amplitude. This discovery could have significant fundamental importance. Associated with this leap, to a bandwidth of nearly 50 Stokes shifts, is a wealth of possible applications and a goldmine of new physics.

One potential application is in the field of nuclear fusion. Efficient targets in inertial confinement fusion (ICF) require collisional absorption to be the dominant process in the laser-target coupling. Analyses have predicted that a simple increase in the frequency bandwidth of the incident light can effectively inhibit unwanted instabilities such as backscattering. This approach has been suggested for ICF but, to date, has remained unexplored because the lasers normally employed in laser fusion research has relatively small bandwidth . The model equations which describe multifrequency SRS are fundamental and can also be used to model phenomena which are physically quite different, such as beat-wave generation in plasma physics. Thus the full impact of our results is hard to evaluate at this stage.

Fig. 1 shows the type of output spectrum predicted for resonant symmetric pumping. The horizontal axis assigns a component number to each of the generated frequencies (the waves at the pump frequencies are numbered 0 and -1). The vertical axis calibrates the time domain and allows one to interpret the time for the spectrum to switch-on (an important experimental parameter) and also the variation of pulse lengths across the comb of frequencies. In Fig. 2 we show a particularly novel characteristic of this new broadband interaction phenomenon. Over wide ranges of parameters, the generated frequencies collectively organise themselves into particularly simple configurations. At each frequency a "row" of stable Raman soliton pulses spontaneously forms. A temporal snap shot of the intensity profile of just one of these "soliton rows" is shown.

References.
1. L. L. Losev and A. P. Lutsenko, Kvantovaya Electron. (Moscow) **20**, 1054 (1993).
2. G. S. McDonald, G. H. C. New, L. L. Losev, A. P. Lutsenko and M. Shaw, (to appear in Opt. Lett. 1994).

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Figure 1. Light pulses in the generated Raman spectrum.
Figure 2. Stable Raman soliton trains are spontaneously generated in the time domain.