Dissipative solitons generated from a mode-locked Raman laser

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Stolen, *et al.* introduced synchronously pumped oscillators where gain was achieved through stimulated Raman scattering (SRS) as a method to reach wavelengths outside of the limited range covered by laser gain media [1]. Raman lasers are thus pumped by another laser source and generate a frequency-shifted Stokes (or anti Stokes) wave. Raman solitons which are generated by this technique typically require km-long cavities, require anomalous-dispersion fibers and are limited to low pulse energies [2]. Self-similarly evolving parabolic pulses have also been generated, but required km-long fibers and achieved 6 ps duration [3]. Here, we present a new type of Raman oscillator, which supports dissipative solitons, does not require anomalous dispersion and a km-long cavity.

The experimental setup (Fig1.a) consists of a pump source and the Raman resonator. The pump source is comprised of a mode-locked oscillator generating linearly chirped 6.5-ps pulses with 37 MHz repetition frequency at 1065 nm. When the pump pulses are coupled into the amplifier, further amplified to 760 mW of average power (without feeding the output back into the amplifier), we observe a weak Stokes wave forming around 1120 nm. Next, we arrange for the Stokes component to be fed back into the Raman resonator, while filtering out the pump . We use a translation stage to arrange to synchronize and temporally overlap the seed pulses at 1065 nm and the Stokes wave at 1120 nm precisely, which is confirmed by time-domain measurements. When temporal overlap is achieved, the amplified spectrum is modified dramatically, with most of the energy being transferred to the Stokes wave at 1120 nm with 16 nm spectral width (Fig1.c).

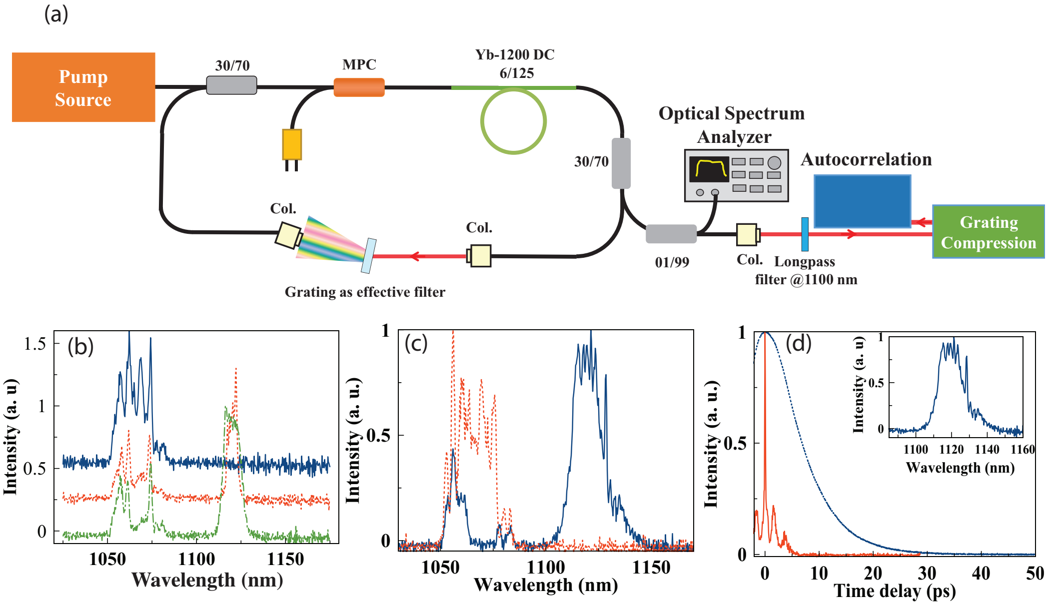

Fig. 1 (a) Schematic of the setup: MPC, multi-pump signal combiner; DC, double clad; WDM, wavelength-division multiplexer; HP, high power; Col., collimator. (b) Spectra of Raman laser at output power 0.6 W (solid line), 1.1 W(dotted line), and 1.3 W (dashed line).(c) Optical spectra without feedback (dotted line) and with feedback (solid line) (d) Intensity autocorrelation trace of uncompressed Raman pulse (dotted line) along with compressed (solid line). Inset: Raman spectrum centered at 1120 nm with 17 nm spectral width.

In conclusion, we present a novel type of Raman oscillator. The Raman gain acts as a temporal gate and a spectral filter. Consequently, the pulses at the Stokes wavelength arise from an interplay of Kerr nonlinearity, dispersion, spectral filtering, gain and loss, akin to dissipative solitons described by the complex Ginzburg-Landau equation [4]. Meanwhile, the resonator structure resembles an optical parametric oscillator more than a typical Raman laser. The intra-cavity energy of Raman pulses are $\sim$10 nJ. The pulses are dechirped in a standard grating compressor to 135 fs (Fig 1(d)).

References

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