Broadband stimulated Raman Scattering (SRS) spectroscopy based on photonic time stretcher without use of lock-in detection

Vikas Kumar, Francesco Saltarelli, Francesco Crisafi, Daniele Viola, Giulio Cerullo and Dario Polli

IFN-CNR, Dipartimento di Fisica, Politecnico di Milano, Piazza Leonardo da Vinci 32,20133 Milan, Italy

nasavikas@gmail.com

Abstract: Coherent Raman scattering (CRS) microscopy is a well-known non-invasive technique capable of high speed, label-free imaging of biological cells and tissues, based on their intrinsic molecular vibrational response. Coherent anti-Stokes Raman scattering (CARS) and stimulated Raman scattering (SRS) are the two most commonly used CRS techniques. As compared to CARS, SRS exhibits several advantages: the signal is linearly proportional to species concentration and is free of nonresonant nonlinear background. SRS acquisition requires high-speed modulation and synchronous lock-in detection to measure the tiny (10^{-4} to 10^{-5}) differential signal sitting on a large linear background. 'Single colour' SRS imaging has been demonstrated up to video-rate speed, however 'broadband' SRS is more informative but technologically challenging to implement. We introduce here a novel approach to perform broadband SRS.

Our approach is based on photonic time stretcher (PTS) [1]. The broadband Stokes pulse, after interacting with the sample, is stretched by a telecom fiber to ≈15ns, mapping its spectrum in time (Fig. 1a). The SRG signal ('pump-on minus pump-off 'Stokes spectra, further normalized by Stokes spectra) is sampled through a fast analog-to-digital converter (Teledyne LeCroy Waverunner 8254M: 2.5 GHz bandwidth, 40 GS/s, 8-bit resolution), providing single-shot spectra at 80-kHz rate. We demonstrate ≈10^{-5} sensitivity over ≈500cm^{-1} in the C-H region.

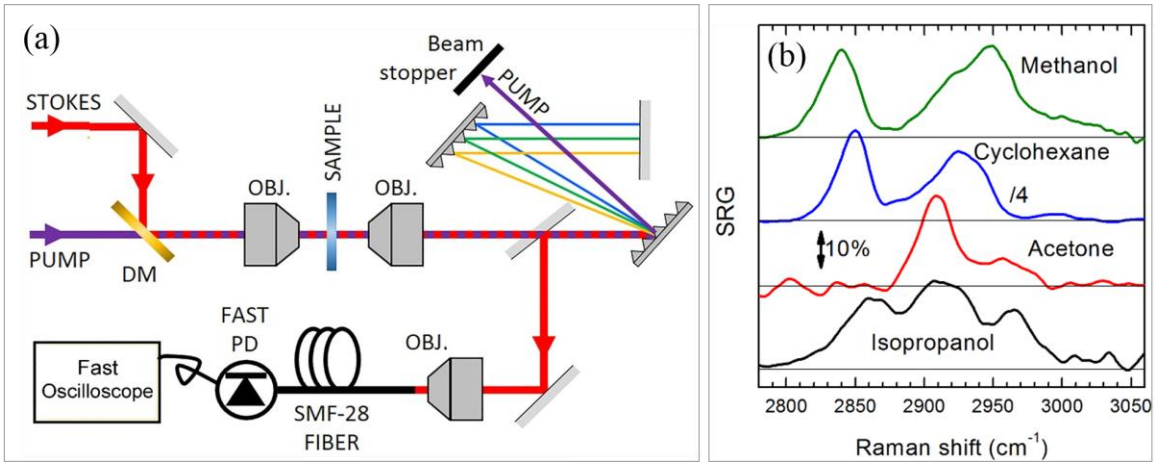

Fig. 1: *(a) Schematic setup of the PTS-SRS. DM: Dichroic mirror, PD: photodiode. (b) SRS spectra of different solvents, averaged over 8 consecutive pulses (100μs acquisition time). Pump energy was 200nJ on the sample. The cyclohexane signal has been divided by 4 for comparison.*

References:

[1] Fard, A.M., Gupta, S. and Jalali, B. "Photonic time-stretch digitizer and its extension to real-time spectroscopy and imaging," *Laser Photonics Rev.* **7**, 207 (2013).