RELATIVE INTENSITY NOISE MEASUREMENTS OF FEMTOSECOND LASER BEAMS IN SRS MICROSCOPE

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In this paper relative intensity noise measurements of three femtosecond laser sources, a Ti:Sapphire (Ti:Sa) oscillator, a femtosecond synchronized optical parametric oscillator (OPO) and a second Harmonic Generator (SHG), are reported and discussed.

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1. Introduction

Stimulated Raman Scattering (SRS) microscopy affords high chemical selectivity of unlabeled living cells, and in addition, implement real time three-dimensional imaging with high spatial resolution and sensitivity. In SRS microscopy, two collinear laser beams, a high-power pump laser and a low power Stokes laser with different frequencies ($\omega_L > \omega_S$), are focused into a sample. When their difference matches the vibrational frequency of the molecular bonds of interest, energy is transferred from the pump beam to the probe beam, observable in an increase in probe signal intensity (Stimulated Raman gain, SRG) and a decrease of the pump signal intensity (Stimulated Raman Loss, SRL) [1-5].
In our previous paper [6], we reported the design and the implementation of a microscope based on femtosecond Stimulated Raman scattering (fs-SRS), which is able to cover all the regions of Raman spectra: the fingerprint region (400 cm^{-1} – 1600 cm^{-1}), the silent region and the C-H region (greater than 2700 cm^{-1}). The experimental imaging setup is equipped with three femtosecond laser sources: a Ti:Sapphire (Ti:Sa), a femtosecond synchronized optical parametric oscillator (OPO) and a second Harmonic Generator (SHG). In order to cover all the regions of Raman spectra, they can be used in two different combinations. The first one, using Ti:Sa and OPO+SHG, we can cover in SRL modality the fingerprint region and the silent region. The second one, using Ti:Sa and OPO, we can cover the C-H region in SRG modality. The system, not commercially available, is the result of the integration of a femtosecond stimulated Raman spectroscopy set up with C2 confocal Nikon microscope, which is made up by an inverted Nikon Ti-eclipse microscope and a scan head.

The random fluctuations of the frequency (or phase) and amplitude of the electromagnetic field of a laser play a fundamental role in many applications. Of course, the effects of laser noise are undesirable and noise should be controlled and reduced to the acceptable levels. The knowledge of its power spectral density provides the basis for reducing the frequency or amplitude fluctuations eventually down to the standard quantum limit (SQL) or shot-noise level.

In this paper relative intensity noise measurements of three femtosecond laser sources, a Ti:Sapphire (Ti:Sa) oscillator, a femtosecond synchronized optical parametric oscillator (OPO) and a second Harmonic Generator (SHG), obtained using a radiofrequency spectrum analyzer (Rohde & Schwarz FS300) are reported and discussed. We demonstrated that the use of a third laser source does not induce a deterioration in the performance of our imaging system.

References

1. R. Ranjan, M. A. Ferrara, A. Filograna, C. Valente and L. Sirleto. Journal of Instrumentation, vol. **14,** P09008, (2019).
2. Ranjan, R., Indolfi, M., Ferrara, M. A., Sirleto, L. J. Vis. Exp. (149), e59614, (2019).
3. Ferrara MA, Filograna A, Ranjan R, Corda D, Valente C, Sirleto L. PLOS ONE 14(5): e0216811, (2019).
4. Annalisa D'Arco, Maria Antonietta Ferrara, Maurizio Indolfi, Vitaliano Tufano and Luigi Sirleto. Journal of Nonlinear Optical Physics & Materials Vol. 26, No. 4, 1750052, (2017).
5. D'Arco A., Brancati N., Ferrara M. A., Indolfi M., Frucci M., and Sirleto L., Biomed. Opt. Express, 2016, 7, (5), pp. 1853-1864, (2016).
6. R. Ranjan, A. D'arco, M. A. Ferrara, M. Indolfi, M. Larobina and L. Sirleto. Opt. Exp., Vol. 26, Issue 20, pp. 26317-26326, (2018).