Stimulated Raman excitation with ultrasound detection

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Abstract: Molecular specificity affordable through stimulated Raman excitation can be combined with high-frequency ultrasound detection allowing chemically specific sensing and imaging in scattering media.

Photoacoustic (PA) Raman spectroscopy [1] was originally proposed and developed as the way to improve the sensitivity of Raman spectroscopy measurements at the times, when photomultiplier tubes and photodiodes lacked the sensitivity. However, the greatest advantage of utilizing ultrasound waves for detection comes from their low scattering in optically turbid media, thus, providing the means to attain spatial information about molecular species through PA microscopy [2] or PA tomography [3] imaging. Recently, we were able to successfully utilize stimulated Raman photoexcitation mechanism for PA imaging [4-5]. In this report I attempt to understand the sensitivity limits of this detection and the ways to improve in order to achieve label-free, chemically-specific imaging of deep-tissue structures not only with great specificity, but sensitivity as well.

In order to compare the sensitivity of optical and ultrasound detection, we used mineral oil as a model system, which has Raman spectrum similar to the one of lipids. We found that photoacoustic signal is highly correlated with the optical system detected through stimulated Raman scattering process (Fig. 1). However, a commercially available ultrasound transducer with a specified sensitivity of 10 kPa and bandwidth 10 MHz was nowhere near the sensitivity of optical detection, which could be as low as single photon sensitive. In my talk I will discuss the ways of improving the signal strength both in transparent and scattering media and on enhancing the sensitivity of high-frequency ultrasound detection.

References: