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Raman spectroscopic applications: from physics to biology and medicine

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Contemporary laser research includes the development of laser spectroscopic techniques to understand the microscopic structural aspects in materials, chemicals or biology. In particular, laser Raman spectroscopy, which provides bond specific information, has attracted considerable attention. Over the last decade, many nonlinear Raman techniques, such as Coherent Anti-Stokes Raman scattering (CARS), picosecond Optical Kerr-Gate Raman and Stimulated Raman scattering (SRS), have been developed to obtain molecular structural and dynamical information with a good signal to noise ratio and with efficient fluorescence rejection compared to conventional Raman spectroscopy. Yet, these methods suffer from some difficulties such as signal distortion due to non-resonant structure less background in CARS, incomplete fluorescence elimination adding to noise in Kerr-Gate effect and experimental complexity. We have developed a nonlinear technique, which we refer to as “Ultra-fast Raman Loss Spectroscopy (URLS)” that has many unique advantages over other methods. URLS is an analogue of SRS but more sensitive. It involves the interaction of the two laser sources, *viz.* a picosecond (ps) pulse and a femtosecond white light (WL), with a sample leading to the generation of loss signal on the higher energy (blue) side with respect to the wavelength of the ps pulse unlike the gain signal observed on the lower energy (red) side in SRS. These loss signals are at least 1.5 times more intense than SRS signals. Also, the very prerequisite of the experimental protocol for signal detection to be on the higher energy side by design eliminates the interference from fluorescence, which appears on the red side. Unlike CARS, URLS signals are not precluded by non-resonant background under resonance condition and also being a self-phase matched process is experimentally easier. Thus, the rapid data acquisition, natural fluorescence rejection and experimental ease ascertain Ultra-fast Raman loss scattering (URLS) as a unique valuable structure determining technique.

In the second part, we would highlight the fundamental and applied research in biophotonics, with particular emphasis to biology and medicine. For example, in biology, the ability to use laser microscopy down to one micrometer resolution (in some cases even to diffraction limit) provides access to the nucleus in a single cell. Thus one can learn about the molecular constituents and therefore monitor the dynamical process in cell functioning, albeit, the processes are slow. Similarly, in medicine, examples, include, microscopic studies on brain and tissues etc, would be discussed.