Ultrafast processes in biomolecules and condensed matter compounds unveiled by nonlinear Raman spectroscopy.

One of the main challenges for modern scientific inquiries is the study of out-of-equilibrium molecular and solid-state compounds dynamics with atomic spatial resolution. Tremendous challenges exist in understanding the ultimate nature of such processes, as they occur on the ultrafast (sub-picosecond) timescale of atomic motion. The impressive technological improvements in the last decades, especially the advent of bright femtosecond laser sources, paved the way to a direct exploration of these temporal realms and have been foundational to ultrafast spectroscopy, in which laser pulses are used to first excite (pump) and subsequently interrogate (probe) a system. Critically, the natural hindrance for such time-resolved inquiries revolves around the simultaneous need of two key ingredients: temporal and spectral resolutions, which are mutually compromised due to the Fourier limit. In this presentation I will discuss how coherent nonlinear Raman techniques disclose the chance for circumventing such limitations, accessing vibrational spectroscopy on sub-picosecond time regimes. Specifically, I will show how, by combining experimental nonlinear Raman spectroscopy with appropriate theoretical modelling to interpret the measured signals, we can obtain a detailed mapping of the ultrafast photo-physics in both organic systems as well as solid-state compounds.