Quantum optics with organic molecules

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Single organic molecules are commonly used as probes in material science and are promising contestants for realizing quantum optical platforms [1]. Nevertheless, the large number of vibrational, electronic and photonic degrees of freedom have limited their research to interaction scenarios where some of their consequences are neglected or traced out. In this talk I present our efforts to study and consider those degrees of freedom on equal footing [2,3,4,5,6]. Specifically, we will show the engineering of nanophononic structures that enables us to predict enhancements of the optical coherence of solid-state molecules by orders of magnitude beyond the current experimental status [2]. Moreover, we will illustrate how the treatment of nanocavities interactions with fundamental molecular principles [3, 4] allows for microscopic derivations of optomechanical models of Surface enhanced Raman scattering (SERS) [7,8]. This formalism opens cooperative mechanisms between both resonant and non-resonant electronic Raman components that drastically modify the heights of SERS peaks and the generation of enhanced nonclassical correlations between Stokes and anti-Stokes photons [4]. Lastly, by means of exploiting intense laser excitations to drive polar dipole transitions enhanced by nanocavities, we present our proposal of a tunable single-photon source operating in the terahertz (THz) range [6], which can open the road for novel quantum optics sources and experiments in this frequency regime [4].

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