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Exploiting Nanoscale Optics Fields to Control Light-Matter Interactions with Applications Spanning Quantum Optics to Photo-Catalysis

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Since Purcell's seminal report 75 years ago, electromagnetic resonators have been used to control light-matter interactions to make brighter radiation sources and unleash unprecedented control over quantum states of light and matter. Indeed, optical resonators such as microcavities and plasmonic antennas offer excellent control but only over a limited spectral range. Strategies to mutually tune and match emission and resonator frequency are often required, which is intricate and precludes the possibility of enhancing multiple transitions simultaneously. Here I will discuss approaches where resonances are not necessary for controlling light-matter interactions; instead, we use waveguide capable of focussing and defocussing light to the 10 nm scale. Using this approach, my team has reported strong enhancements of light emission over broad frequency ranges. In this talk, I will discuss cases studies evaluating the enhancement of nonlinear frequency mixing, spontaneous emission and Raman scattering to showcase the generality of the approach. In the case of our Raman studies, I will discuss how we are using this approach to study the interaction of light, electrons, and molecular vibrations to better understand physical mechanisms in photo catalysis.