Extreme optical nonlinearities emerge when photons are spatially confined and rendered mutually interacting. Semiconductor optical microcavities are promising solid-state systems wherein these two conditions can be simultaneously fulfilled. Photons in a microcavity can couple strongly to excitons in semiconductor quantum wells, giving rise to composite light-matter quasi-particles known as polaritons. The excitonic constituent confers polaritons giant interaction strengths, while the photonic constituent enables micron-scale confinement of polaritons followed by photon emission. Hence, polaritons constitute an excellent system for studying light-matter interactions under the influence of tunable coupling, driving, nonlinearity, and dissipation. In addition to single-mode nonlinearities, coupled polariton modes exhibit rich nonlinear dynamics and steady-states due to the interplay between nonlinear interactions and linear coupling. Here, we will present recent experimental results on coupled semiconductor micropillars exhibiting such strongly nonlinear optical dynamics and steady-states.

Our group has demonstrated several hallmark features of nonlinear Josephson oscillations in a photonic system. The system studied consists of two strongly coupled semiconductor micropillars. In the linear regime (low pump power), polaritons harmonically oscillate between the two pillars. For increased pumping, the oscillations become anharmonic. For even higher pumping, polaritons are trapped by the intensity-induced nonlinearity in the pumped pillar. This intriguing phenomenon, known as macroscopic self-trapping, was recently observed for the first time in a photonic system. Recently, we have studied the steady-states of coupled polariton modes under resonant excitation. Due to the interplay of interference and nonlinearity in this system, three distinct density profiles can be observed under identical driving conditions, i.e. tristability. Through interferometry measurements we evidence how the relative phases of two coupled cavities can be fully controlled by means of effective polariton-polariton interactions.

Keywords: polariton, strong light-matter coupling, nonlinear optics

References:


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