# Cavity quantum electrodynamics effects in resonantly excited strongly-coupled quantum dot – micropillar cavities

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Resonant excitation of quantum systems offers the unprecedented possibility of coherent control important for both fundamental study and applications due to minimized dephasing and direct addressing of a chosen state, enabling observation of phenomena not accessible otherwise. In the active field of cavity quantum electrodynamics (cQED) resonant excitation has so far been used to observe strong coupling between quantum dot (QD) exciton (X) and cavity mode (CM) [1] as well as cavity-enhanced dressing of QD X and biexciton [2].

We employed resonance fluorescence (RF) to study cQED effects in strongly coupled InGaAs/GaAs QD-micropillar system. An advanced 90 degree excitation/detection scheme enabled to drive directly the QD X (in-plane excitation) which then couples to the cavity. Spatial and polarization filtering was used to extract the signal. Driving the QD X directly enables realization and observation of fingerprints of the strongly-coupled system for arbitrary laser detunings as the system is not pumped through the CM. Continuous wave excitation with tunable semiconductor laser with 100 kHz linewidth was used to excite the system and cavity spectrum (losses through the upper DBR) was measured in the vertical direction (parallel to the micropillar axis). For QD off-resonant with respect to the cavity a typical saturation behavior was observed. Both direct RF and CM-mediated signal was measured providing info about off-resonant QD X-CM coupling. When QD X transition is resonant with the CM it can be most efficiently excited through the bare (uncoupled) QD state (laser on resonance with the QD X) due to small pure dephasing and purely excitonic character of the pumped state being eigenstate of the system. In that case clear Rabi doublet can be observed. When the QD-laser detuning is varied and the laser energy is scanned over the strongly-coupled system, much weaker and asymmetric response at the energy of the two polariton branches was detected. Varying the excitation power on mutual resonance of the laser field QD X and the CM shows that the eigenstates of the system are determined by relative coupling strengths in the system: At low excitation the laser field is used only to populate the system and clear features of the strong QD X-CM coupling are visible. In the intermediate regime a hybrid system is formed whereas for higher excitation dressing of the polariton branches takes place and a related Mollow triplet-like can be observed in the spectrum. The transition between the regimes was proven experimentally by observation of a clear maximum in the RF signal of the strongly-coupled system as a function of excitation power. Theoretical analysis of the system was performed within the Fourier-transformed first-order autocorrelation function approach including multi-photon scattering.

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