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Open system quantum optics with quantum dots and semiconductor chips

Semiconductor cavity structures can incorporate semiconductor quantum dots allowing fundamental control of light-matter interaction processes in a nanophotonics environment. Two commonly studied examples in quantum optics include the Purcell effect, where the spontaneous emission rate is enhanced by coupling to a confined cavity mode, and the Mollow triplet, where a driven two-level system emits a triplet of resonances.
This talk will first describe why the usual Purcell factor formula is ambiguous and does not work in general, and I will introduce the “fix” [1]. Second, I will describe the resonance fluorescence spectra of a driven quantum dot placed inside a semiconductor cavity and interacting with an acoustic phonon bath [2]. A series of light-matter interaction regimes are introduced, including phonon-mediated incoherent excitation [3], excitation-induced dephasing [4] and phonon-induced inversion [5].

[1] P. Kristensen, C. Van Vlack, and S. Hughes, Generalized mode volume for leaky optical cavities, Optics Letters 37, 1649 (2012)
[2] C. Roy and S. Hughes, Phonon-dressed Mollow triplet in the regime of cavity-QED: Excitation-induced dephasing and nonperturbative cavity feeding effects, Phys. Rev. Lett. 106, 247403 (2011)
[3] S. Weiler., A. Ulhaq, S. M. Ulrich, D. Richter, M. Jetter, P. Michler, C. Roy, and S. Hughes, Phonon-assisted incoherent excitation of a quantum dot and its emission properties, Phys. Rev. B Rapid Communications 86, 241304 (2012)
[4] S. M. Ulrich, S. Ates, S. Reitzenstein, A. Löffler, A. Forchel, and P. Michler, Dephasing of triplet-sideband optical emission of a resonantly driven InAs/GaAs quantum dot inside a microcavity, Phys. Rev. Lett. 106, 247402 (2011)
[5] S. Hughes and H. J. Carmichael, Phonon-mediated population inversion in a semiconductor quantum-dot cavity system, N. J. of Physics 15, 053039 (2013)

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