Quantum Dynamics of a Strongly Coupled Single Quantum Dot-Cavity System

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Abstract

The potential applications of semiconductor quantum dots confined in a microcavity in quantum information processing have generated considerable research efforts in recent years. In such dot-cavity systems, exciton in quantum dots constitutes an alternate two-level system instead of the usual two-level atomic system and the nanocavity with a small volume and high Q is fabricated by micropillar, microdisk and photonic crystal slab. In the present talk, I shall demonstrate the quantum dynamics of a strongly coupled single quantum dot-cavity system coupled a phonon bath in terms of a perturbation treatment based on a unitary transformation and an operator displacement. A damped vacuum Rabi oscillation in the strong coupling regime is predicted in such a dot-cavity system. The decoherence induced by acoustic phonons as a function of the detuning between the cavity mode and exciton is obtained analytically. It is shown that the detuning has a significant impact on the quantum-dot exciton lifetime. In the experimental conditions, the larger the detuning, the longer the quantum-dot exciton lifetime, which is in good agreement with the recent experimental results [K.Hennessy et al., Nature 445, 896 (2007)].