Coherent control of quantum dot excitons by optic and optoelectronic manipulation

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Abstract:

In optical experiments on single self-assembled InGaAs quantum dots the exciton ground state transition appears as two-level system with a lifetime limited line width of a few µeV [1]. For the case of pulsed laser fields and in the absence of decoherence, the ground state exciton represents a qubit. Excitations with ps laser pulses result in multiple qubit rotations, which are demonstrated in a quantitative way as Rabi oscillations in photocurrent experiments [2, 3]. Controlled coherent state preparation in terms of excited state Rabi flopping can be applied to implement single photon emission from deterministically generated single exciton states [4].

As a function of electric field induced detuning we observe Ramsey fringes of a single exciton qubit for double pulse excitation [5, 6]. In those experiments we are able to demonstrate voltage controlled qubit manipulations within a wide range of pulse delays. For pulse delays beyond 500 ps we observe Ramsey fringes with a spectral half period below 3 µeV, which is less than the homogeneous linewidth of the quantum dot.

Using fast electric signals, which are phase-locked to ps-laser pulses, we further demonstrate the coherent control of an exciton qubit by electric switching [7]. Voltage controlled qubit manipulations as demonstrated in this work, seem to be essential for new types of optoelectronic quantum gates, precision quantum measurements, and novel applications in the field of coherent optoelectronics.

Literature:

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