Phonon-assisted tunneling of excitons between two self-assembled laterally spaced quantum dots

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Abstract

In this work we explore exciton relaxation processes in two coupled quantum dots (QDs). The system under consideration is formed by two laterally spaced self-assembled InGaAs dots in a GaAs matrix. We study electron and hole states in a realistic model which takes into account the strain and material distribution. Using the configuration-interaction method we calculate the energies of the exciton states. We investigate phonon-mediated processes for excitons and show that relaxation between spatially direct exciton states is very slow. We investigate also phonon-mediated transitions between different electron and hole subshells ('s' and 'p' states).

Systems composed of QDs can be used for designing quantum-coherent devices, including QD-based quantum bits. Studying the relaxation and carrier transfer processes between optically active exciton states provides a link to optical experiments. Our results indicate that exciton tunneling between nearly degenerate spatially direct states is inefficient, which suggests that two-phonon processes may play an important role in the carrier transfer.

Our model is based on a kp approximation for a single particle in a strained self-assembled structure [1]. Then we include Coulomb interaction between electrons and holes within standard configuration-interaction approach [2]. Finally, the Fermi golden rule is used to obtain the relaxation rates between the two lowest energy eigenstates. In order to investigate occupation of exciton states as a function of time, we model the dynamics using the Linblad equation.

References

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