Optimal quantum control of multiple quantum dot exciton qubits using femtosecond pulse shaping

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The ease and efficiency of coherent optical control of fundamental charge and spin states in semiconductor quantum dots (QDs) makes these materials promising for realizing the building blocks of a solid state quantum computer. Optimal quantum control techniques may be used to tailor the QD-light coupling, providing a direction for optimizing the speed and fidelity of elementary quantum gates as well as the pursuit of complex-instruction-set quantum computing. This potential was recently illustrated through the application of femtosecond pulse shaping to the theoretical optimization of a C-ROT gate involving two exciton qubits in a single QD [1], and the experimental demonstration of a parallel single qubit gate involving two excitons in distant quantum dots [2]. Through pulse shape optimization, here we demonstrate numerically that simultaneous high fidelity SU(2) rotations on excitons in multiple quantum dots are feasible with suitable pulse shapes. We also report the achievement of adiabatic rapid passage (ARP) on the exciton in a single semiconductor QD on a subpicosecond time scale experimentally [4], representing a 20-fold reduction in the gate time for ARP in comparison to previous work [3].

[1] Mathew et al. Phys. Rev. B 84, 205322 (2011).

[2] Gamouras et al. Nano Letters 13, 4666 (2013).

[3] Wu et al. Phys. Rev. Lett. 106, 067401 (2011); Simon et al. Phys. Rev. Lett. 106, 166801 (2011).

[4] Mathew et al. Phys. Rev. B 90, 035316 (2014).