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Abstract

Fast Biexciton Preparation in a Quantum Dot Using On-Off Pulses †

Dionisis Stefanatos * and Emmanuel Paspalakis

Materials Science Department, School of Natural Sciences, University of Patras, 26504 Patras, Greece; paspalak@upatras.gr

* Correspondence: dionisis@post.harvard.edu

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Abstract: The manipulation of exciton and biexciton transitions in semiconductor quantum dots using laser pulses is an active research area, embodying various theoretical and experimental investigations. Within this context, a problem which has attracted significant attention is the coherent preparation of the biexciton state, when the quantum dot is initially in its ground state. A basic approach employs a linearly-polarized single laser pulse that drives the exciton-biexciton cascade with a two-photon transition between ground and biexciton states. The two frequently used laser pulse shapes are the constant and hyperbolic secant profiles. In this work, we show that a simple on-off-on pulse-sequence, with pulse durations obtained from the solution of a transcendental equation, can achieve complete preparation of the biexciton state faster than the commonly used constant and hyperbolic secant pulses. Moreover, using numerical optimal control, we demonstrate that for a wide range of values of the maximum pulse amplitude, the proposed pulse-sequence prepares the biexciton state in the minimum possible time, thus provides the quantum speed limit of the system (for fixed maximum control amplitude). We finally show with numerical simulations that, even in the presence of realistic dissipation and dephasing, high levels of biexciton state fidelity can be generated in short times.

Keywords semiconductor quantum dots; biexciton; quantum control; coherent control; quantum speed limit

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