Deterministic Writing and Control of the Dark Exciton State using Short Single Optical Pulses

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We demonstrate for the first time that the quantum dot-confined dark exciton forms a long lived (> 1 microsec) integer spin qubit which can be deterministically initiated and fully controlled by short optical pulses, several orders of magnitude shorter than the life and coherence time (at least 100 ns) of the qubit. An absorption resonance to one out of the two DE eigenstates was identified using photoluminescence (PL) and PL excitation spectroscopy. The DE presence can then be detected optically via excitation to a spin-blockaded biexcitonic state which radiatively decays. The emission intensity of this decay is directly related to the population and spin state of the DE. Using this technique, we demonstrate Rabi oscillations in the DE pulse excitation intensity dependence. We identify the energy required for pi and 2pi pulses, thus demonstrating that the DE can be optically written on-demand.

This deterministic initialization of the DE is then used to demonstrate control of the DE spin state in a manner similar to the control of the bright exciton. Our novel demonstration of on demand DE initialization in a pure spin state by a single optical pulse and its full optical control in the absence of external fields, suggest that the DE forms an excellent spin qubit, on par or even superior to the spin qubits formed by its constituents, the electron or hole separately.