Magnetic-Field Control of Photon Echo from the Electron-Trion System

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Coherent optical phenomena in atomic ensembles and other systems with discrete energy level structure attract a lot of attention for realization of optical quantum memories. One of these phenomena is the photon echo where in the classical picture an intense optical pulse results in rephasing and retrieval of the macroscopic medium's polarization, which was created before by another optical pulse. Currently experimental realizations of quantum light-matter interfaces are based on alkali atoms or strongly isolated impurity centers like rare earth ion crystals. Semiconductor nanostructures have not been considered mainly due to their large decoherence rates and their complex energy level structure. However, compared to isolated atoms the fundamental optical excitation in semiconductors, the exciton, has a large dipole moment, which allows fast operation (below 1ps). Moreover recent developments in optical control of charged excitations in semiconductors nanostructures (trions) open new possibilities in which the long-lived electron spin in the system's ground state can be used as single qubit.

In this work we develop the novel and simple approach to control the photon echo amplitude by application of a transverse magnetic field [1]. For demonstrational purposes we use the electron-trion system in a CdTe semiconductor quantum well where the neutral and charged (trion) excitons are spectrally well separated. Exploiting the Larmor precession of electron spins about the transverse magnetic field we demonstrate transfer of coherence between optically accessible and inaccessible pairs of states. As the result the photon echo signal exhibits oscillatory behavior, which depends sensitively on the polarization configuration of the exciting and refocusing pulses. The echo amplitude can be fully tuned from the maximum down to zero depending on the time delay between the two pulses and the magnetic field strength. The results are explained in terms of the optical Bloch equations accounting for the spin level structure of electrons and trions.

[1] L. Langer, S.V. Poltavtsev, I. A. Yugova, D. R. Yakovlev, G. Karczewski, T. Wojtowicz, J. Kossut, I. A. Akimov, and M. Bayer, "Magnetic-Field Control of Photon Echo from the Electron-Trion System in a CdTe Quantum Well: Shuffling Coherence between Optically Accessible and Inaccessible States", Phys. Rev. Lett. **109**, 157403 (2012).