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Conversion of angular momentum from single photons to single electron spins in electrically controlled quantum dots

AKIRA OIWA, Department of Applied Physics, University of Tokyo

Electrical controllability of gate-defined quantum dots (QDs) has brought significant developments in the coherent manipulation of electron spins and two-qubit gate operation toward scalable qubits for quantum computations. Moreover the suitability of gate-defined QDs to quantum information technologies would be considerably enhanced if spin states in the gate-defined QDs could couple to photon states coherently. Here we show that the photon polarization can couple to the spin degree of freedom in gate-defined GaAs QDs. Double QDs were fabricated in AlGaAs/GaAs quantum wells. By synchronizing a pulse laser irradiation with a charge sensing measurement we performed the real-time single photoelectron spin detection in the double QD. First we show that the resonant inter-dot tunneling can offer a robust detection scheme of the single photoelectrons trapped in the double QDs [1]. In the two-electron regime, the inter-dot tunneling of the photoelectrons strongly depends on the relative spin orientation (parallel or anti-parallel) of the two QDs. Therefore by combining the resonant inter-dot tunneling scheme with the Pauli spin effect, we have realized the nondestructive detection of single photoelectron spins. Finally, we demonstrate the angular momentum conversion from single photons to single electron spins in the double QD from the dependence of the detected spins on the incident photon polarization.

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[1] T. Fujita et al, Phys. Rev. Lett. 110, 266803 (2013).