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Nondestructive optical probe of coherent single spin dynamics in a quantum dot[1]

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Understanding the coherent dynamics of a single electron spin in a quantum dot (QD) is important for potential applications in solid-state, spin-based quantum information processing. Here, results will be presented focusing on optical detection of a single spin and observation of the temporal evolution of the spin state. First, we demonstrate the detection of a single electron spin in a QD using a continuously averaged magneto-optical Kerr rotation (KR) measurement [3]. In contrast to many other single spin detection schemes, the KR measurement minimally disturbs the system, making it potentially useful for exploring quantum measurementphenomena or spin-photon entanglement. This continuous single QD KR technique is then extended into the time domain using pulsed pump and probe lasers, allowing the observation of the coherent evolution of an electron spin state with nanosecond temporal resolution [4]. This provides a direct measurement of the electron g-factor and spin lifetime, and additionally serves as a sensitive probe of the local nuclear spin environment. Finally, we perform ultrafast coherent optical manipulation of the electron spin state in the QD using the optical Stark effect [5], where an off-resonant optical pulse induces rotations of the spin state through angles up to π radians on picosecond timescales.

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