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Ultrafast optical spin echo for electron spins in semiconductors

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Spin-based quantum computing and magnetic resonance techniques rely on the ability to measure the coherence time, T2, of a spin system. We report on the experimental implementation of all-optical spin echo to determine the T2 time of a semiconductor electron-spin system. We use three ultrafast optical pulses to rotate spins an arbitrary angle and measure an echo signal as the time between pulses is lengthened. Unlike previous spin-echo techniques using microwaves, ultrafast optical pulses allow clean T2 measurements of systems with dephasing times (T2*) fast in comparison to the timescale for microwave control. This demonstration provides a step toward ultrafast optical dynamic decoupling of spin-based qubits.