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All-optical quantum control operations for a solid-state spin using a lambda (Λ) system[1] C.G. YALE, B.B. BUCKLEY, D.J. CHRISTLE, F.J. HEREMANS, L.C. BASSETT, D.D. AWSCHALOM, Center for Spintronics and Quantum Computation, University of California, Santa Barbara, California 93106, G. BURKARD, Department of Physics, University of Konstanz, D-78457 Konstanz, Germany — The nitrogen-vacancy (NV) center in diamond is a promising solid-state spin qubit due to its spin-selective intersystem crossing (ISC) enabling initialization and readout of its spin state, while the use of microwave magnetic fields typically provides unitary control. Here, we demonstrate an alternate, fully optical technique to initialize, readout, and unitarily manipulate the NV center's spin below 10 K[2]. To do so, we investigate optically-driven processes within an NV-center-based Λ system using time-resolved methods and quantum state tomography. We initialize our qubit into any selectable superposition, or dark state, through coherent population trapping (CPT). Complementary spin-state readout along any basis is realized by measuring the transient photoluminescence emitted during CPT. We achieve unitary rotations of the spin state about any axis by driving stimulated Raman transitions. With these three protocols, we perform all-optical measures of single-spin coherence. Since these techniques do not rely on the NV center's specialized ISC or require on-chip microwave control, they provide a method for probing other potential solid-state qubits, not only those with NV-like structures.

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