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Ultrafast optical entanglement control between two quantum dot spins SAM CARTER, DANNY KIM, ALEX GREILICH, ALLAN BRACKER, DANIEL GAMMON, Naval Research Laboratory — A single electron spin in an InAs quantum dot is very attractive as a qubit since this system is potentially scalable and allows complete quantum control on an ultrafast timescale using optical pulses. While great progress has been achieved with single spin qubits, it is essential for quantum information applications to move toward entangled multi-qubit systems. Two-qubit systems have been studied in electrostatically-defined quantum dots, but their optical functionality remains unexplored. Here we demonstrate ultrafast optical control of two interacting qubits consisting of two electron spins in separate InAs dots. We initialize the system into a spin singlet state using a cw laser. We then manipulate the entangled state of the two spins with single qubit gates (acting only on one spin) by using pulses faster than the exchange interaction. This allows us to generate all four Bell states. Two-qubit gates are obtained either by the natural exchange precession or by using a longer laser pulse that induces a phase shift in the precession. The two-qubit exchange rate (30 GHz) here gives SWAP gate times of 16 ps, the fastest of any candidate for quantum information processing.

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