All optical quantum control of a spin-quantum state and ultrafast transduction into an electric current

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The ability to control and exploit quantum coherence and entanglement drives research across many fields ranging from ultra-cold quantum gases to spin systems in condensed matter. Transcending different physical systems, optical approaches have proven themselves to be particularly powerful, since they profit from the established toolbox of quantum optical techniques, are state-selective, contact-less and can be extremely fast. Here, we demonstrate how a precisely timed sequence of monochromatic ultrafast (~ 2–5 ps) optical pulses, with a well defined polarisation can be used to prepare arbitrary superpositions of exciton spin states in a semiconductor quantum dot, achieve ultrafast control of the spin-wavefunction without an applied magnetic field and make high fidelity read-out the quantum state in an arbitrary basis simply by detecting a strong (~ 2–10 pA) electric current flowing in an external circuit. The results obtained show that the combined quantum state preparation, control and read-out can be performed with a near-unity (≥97%) fidelity.

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