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Coherent electrical manipulation of a quantum dot qubit
MATTHEW POOLEY, RAJ PATEL, ANTOINE BOYER DE LA GIRODAY, IAN FARRER, CHRISTINE NICOLL, DAVID RITCHIE, Cavendish Laboratory, Cambridge University, J. J. Thomson Avenue, Cambridge, CB3 0HE, UK, ANTHONY BENNETT, MARK STEVENSON, MARTIN WARD, NIKLAS SKOLD, ANDREW SHIELDS, Toshiba Research Europe Limited, Cambridge Research Laboratory, 208 Science Park, Milton Road, Cambridge, CB4 0GZ, UK — We demonstrate the initialization and coherent manipulation of a spin-based qubit in a InAs quantum dot (QD), implementing a spin-flip gate with a fidelity of 97%. We will discuss new measurements on the effect of fluctuating nuclear magnetic field which have implications on state initialisation, operation fidelity, and qubit storage time. An exciton spin-state is initialised by absorption of an incident polarised photon. The exciton state of QDs has two spin-eigenstates separated by fine-structure splitting (s), which can be manipulated using applied electric field. Superposition spin-states precess around the Bloch-sphere with an angular frequency $|s|/\hbar$. An electric field is used to vary the rate and axis of the spin-state precession, and thus control the time-evolution of the stored qubit. Nuclear magnetic field fluctuations induce additional random variations in s, the effects of which we investigate to understand the ideal initialisation and storage regime. Subsequent radiative decay maps the spin of the exciton onto the polarisation of the emitted photon. These results demonstrate a photon-spin interface, which has potential applications in scalable optical quantum computing schemes.

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