All optical preparation, storage and readout of a single spin in an individual quantum dot

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Author(s):
V. Jovanov, F. Klotz, S. Kapfinger, D. Heiss, S. Spiga, D. Rudolph, M. Bichler, M. S. Brandt, G. Abstreiter, J. J. Finley

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We demonstrate optical single electron spin-initialization, -storage and -readout in a single self-assembled InGaAs quantum dot using a spin memory device. Single electron spin relaxation is monitored over timescales exceeding ≥30µs, defined only by extrinsic experimental parameters such as the optical detection efficiency. The selective generation of a single electron in the dot is performed by resonant optical excitation and subsequent partial exciton ionization; the hole is removed from the dot whilst the electron remains stored. When subject to a magnetic field applied in Faraday geometry, we show how the spin of the electron can be prepared with a well defined spin projection relative to the light propagation direction simply by controlling the voltage applied to the gate electrode. The spin is stored then in the dot before being read out using an optical implementation of spin to charge conversion, whereby the spin projection of the electron is mapped onto a more robust variable, the charge state of the dot. After spin to charge conversion, we show how the charge occupancy can be repeatedly and non-perturbatively measured by pumping a luminescence recycling transition. The approach is shown to provide a readout signal 104 times stronger per spin when compared to previous methods. In combination with spin manipulation using the optical Stark effect or microwaves, our approach provides an ideal basis for probing spin coherence in single self-assembled quantum dots over long timescales and the development of methods for coherent spin control.

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