Over one hundred microsecond electron spin coherence in an optically active quantum dot

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Optically active spins in III-V semiconductor quantum dots (QDs) have the highest quality optical properties amongst solid-state spin-photon interfaces [1]. Despite the excellent optical properties of this system, preserving a spin state beyond a few microseconds has remained a challenge [2]. In this work, we implement all-optical spin control techniques [3] in GaAs/AlGaAs QDs grown via nanohole infilling [4]. Using a Carr-Purcell-Meiboom-Gill (CPMG) pulse sequence [5] we decouple the spin qubit from the nuclear environment to sustain the electron spin coherence time up to 113(3) μs, a twenty-fold improvement compared to previous results in III-V QDs. Further, the scaling of the coherence time with the number of CPMG π-pulses indicates a near-perfect refocusing of the interaction between the electron and nuclear environment. By intersecting a microscopic model of the CPMG data with nuclear magnetic resonance spectroscopy, we arrive at a comprehensive understanding of the dephasing in this system. Our results demonstrate the possibility of combining near-ideal optical properties with a highly coherent electron spin dynamics in a solid-state platform

Figures

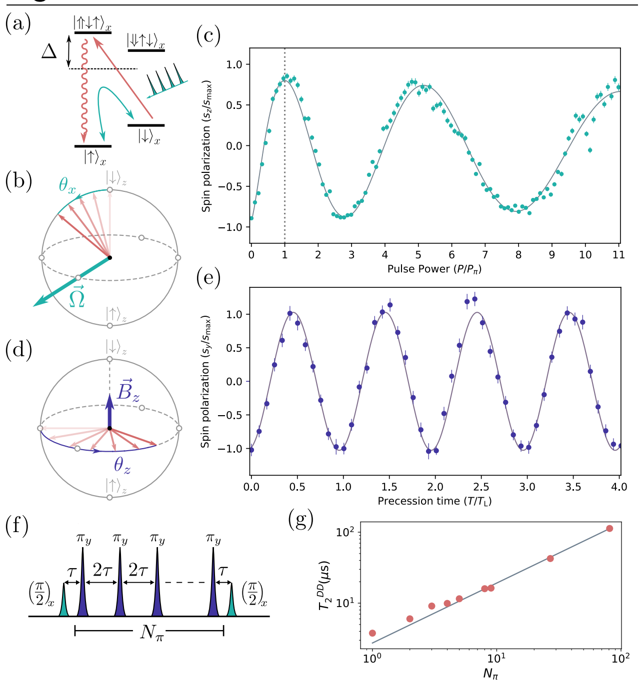

Figure 1: (a) Coherent control (green) and optical pumping (red) of the QD electron spin. (b,c) Rotation of the electron spin around the x-axis, showing characteristic Rabi oscillations dependent on pulse power. (d,e) Larmor precession of the electron spin around the z-axis. (f) CPMG pulse sequence. Successive π_y-pulses decouple the electron from the nuclear environment. (g) Electron coherence time versus number of CPMG π_y-pulses.

References

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