

Complete Coherent Control of Spin Qubits in Self-Assembled InGaAs Quantum Dots under Oblique Magnetic Fields

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Semiconductor quantum dots are promising platforms for quantum information processing and related quantum technologies, offering compact, optically addressable quantum states that can be integrated with photonic structure. A key experimental handle in these systems is the application of an external magnetic field, with the Faraday and Voigt configurations [1]-[3] providing widely used and well-understood operating regimes for spectroscopy and control. Here, we investigate an intermediate, oblique-field geometry in which the magnetic field is applied at an angle relative to the quantum dot symmetry axis, enabling continuous access to regimes between predominantly longitudinal and transverse coupling. Using polarization-resolved micro-spectroscopy on a single InGaAs quantum dot, we track the evolution of the relevant optical transitions as functions of magnetic field magnitude and tilt angle [4][3].

In this configuration, we demonstrate coherent control using detuned (off-resonant) ultrafast optical pulses. We observe Rabi oscillations (Fig.1(a)), Ramsey interference (Fig.1(b)), and we implement universal single-qubit control by realizing general SU(2) rotations (Fig.1(c)), corresponding to complete coherent

control of a qubit encoded in the chiral states of a single InGaAs quantum dot. In our work, the oblique-field approach serves a flexible and experimentally accessible way to identify and address suitable transition pathways for pulsed-based control, complementing standard Faraday/Voigt operation rather than replacing it. These results highlight oblique field operation as a useful addition to the quantum dot coherent control toolbox and a step toward robust gate operations in quantum photonic architectures.

References

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Figures

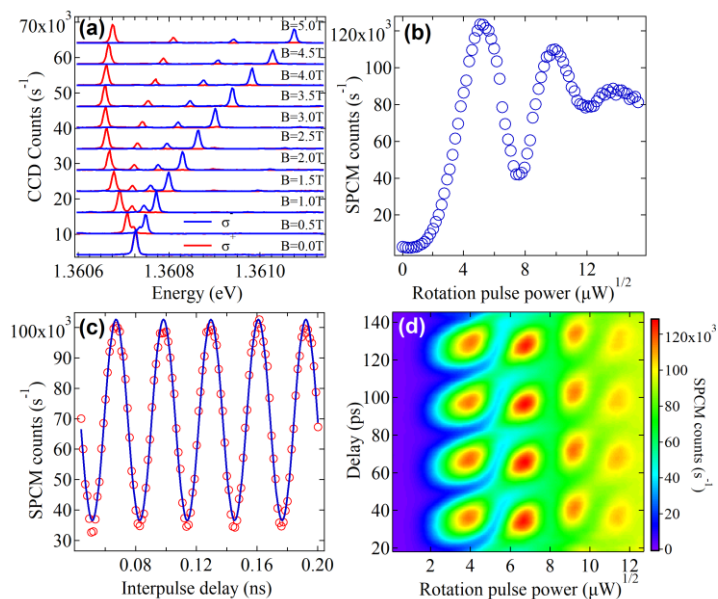


Figure 1: (a) Spectra at different magnetic field strengths (b) Rabi oscillations (c) Ramsey interference fringes (d) SU(2) rotations.