Anisotropic triplet Relaxation for Ge/SiGe Spin Qubits in the Pauli spin blockade regime

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We investigate a Ge/SiGe quantum dot device with a 12-nm-thick Ge quantum well, contacted via etching of the SiGe layer. In planar Ge/SiGe spin qubits, understanding the anisotropy of exchange interactions is crucial for achieving high-fidelity qubit control. Strong spin–orbit coupling and highly anisotropic in-plane g-factors cause deviations from the isotropic Heisenberg model, directly affecting qubit coherence and gate performance [1]. By measuring singlet–triplet oscillations, we map the energy transitions in the system (Fig. 2a) and identify them in the S–T energy diagram (Fig. 2b). From these measurements, we determine the in-plane g-factors for both quantum dots (Fig. 2c) and study singlet–triplet relaxation as a function of time spent in the (1,1) charge configuration and the orientation of the in-plane magnetic field.
This analysis shows that the T0 triplet state exhibits the longest relaxation times, and confirms how relaxation time depends on mixing duration—insights that are critical for optimizing qubit lifetimes and implementing robust two-qubit gates.

References

[1] Geyer et al., Anisotropic exchange interaction of two hole-spin qubits, Nature Physics (2024).
[2] Saez-Mollejo et al., Exchange anisotropies in microwave-driven singlet-triplet qubits, Nature Communications (2025).
[3] Jirovec, Daniel, et al. "A singlet-triplet hole spin qubit in planar Ge." Nature Materials 20.8 (2021): 1106-1112.
[4] Jirovec, Daniel, et al. "Dynamics of hole singlet-triplet qubits with large g-factor differences." Physical review letters 128.12 (2022)

Figures

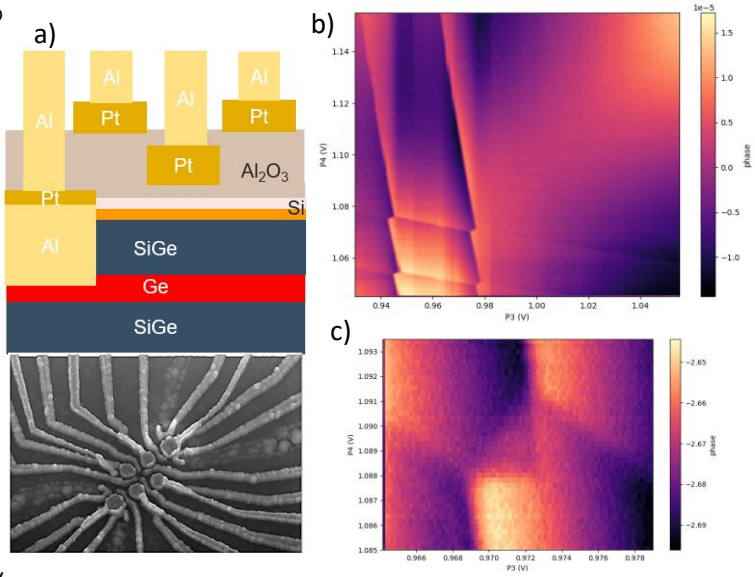

Figure 1: a) Schematic cross-section of the heterostructure together with a scanning electron microscope image of the device. b) Charge stability diagram showing the last-hole regime. c) Pauli spin-blockade triangle in the (1,1)–(0,2) charge configuration.

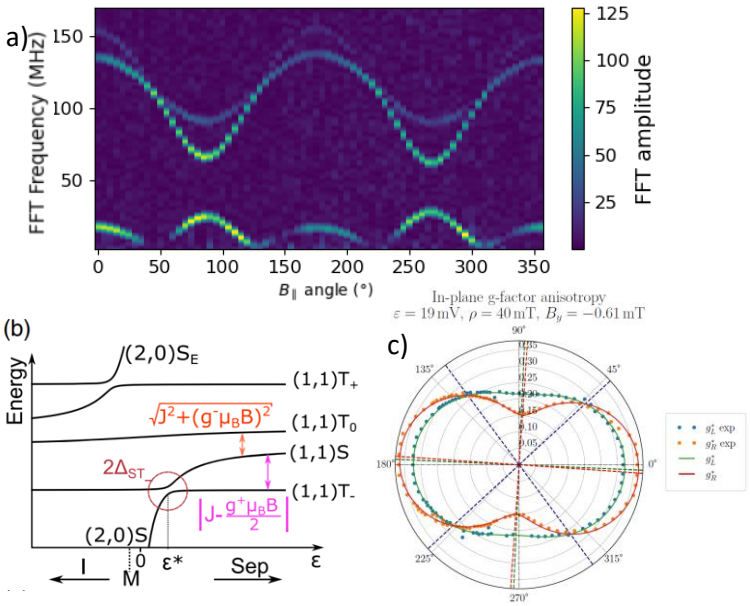

Figure 2: a) FFT of the Singlet-Triplet oscillations occurring as a function of the time spent in (1, 1) charge configuration during the pulse sequence. b) Energy level diagram as a function of detuning [4]. c) Peanut plots computed with the fitted the effective g-factors (g*L and g*R) measured for BII= 30 mT.