# High fidelity gates for GaAs based singlet-triplet qubits by feedback tuning

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Singlet-triplet qubits in double quantum dots allow fast, fully electric control with baseband pulses. However, these pulses are subject to systematic errors due to, e.g., finite rise times and a nonlinear relation between the qubit detuning and the exchange coupling used for control. Furthermore, the dephasing rate arising from electrical noise depends on the operating point. Standard Rabi control does not yield optimal performance, and leakage out of the computational subspace has to be avoided. For GaAs based qubits, an additional challenge is the hyperfine-mediated dephasing due to nuclear spins. We address these difficulties and experimentally demonstrate high fildelity single qubit gates for GaAs based singlet-triplet qubits.

The starting point of our approach is a numerial optimization of the control pulses taking hardware capabilities as well as experimentally measured noise characteristics into account [1]. To eliminate systematic errors due to imperfect knowledge of the device and setup, we employ a self-consistent tuning protocol that iteratively modifies the pulses based on error syndromes obtained from short sequences of gates. By tuning two $\pi/2$ pulses around orthogonal axis simultaneously, effects of state preaparation and measurement errors can largely be avoided. Convergence is typically obtained after a few iterations, while up to 40 free parameters can be adjusted.

Randomized benchmarking of the optimized gates yields an average gate fidelity of up to 99.5 %. A modified randomized benchmarkig protocol allows us to extract a leakage rate of 0.05 %. Further insight on systematic errors is obtained by repeated execution of the gates.

Simulations indicate that the same approach can be extended to exchange-based two-qubit gates for single-triplet qubits while increasing the error rate by only a factor of two.

[1] P. Cerfontaine, T. Botzem, D. P. DiVincenzo, and H. Bluhm, Phys. Rev. Lett. **113**, 150501 (2014).