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Feedback-tuned, noise resilient gates for encoded spin qubits

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Spin 1/2 particles form native two level systems and thus lend themselves as a natural qubit implementation. However, encoding a single qubit in several spins entails benefits, such as reducing the resources necessary for qubit control and protection from certain decoherence channels. While several varieties of such encoded spin qubits have been implemented, accurate control remains challenging, and leakage out of the subspace of valid qubit states is a potential issue. Optimal performance typically requires large pulse amplitudes for fast control, which is prone to systematic errors and prohibits standard control approaches based on Rabi flopping. Furthermore, the exchange interaction typically used to electrically manipulate encoded spin qubits is inherently sensitive to charge noise. I will discuss all-electrical, high-fidelity single qubit operations for a spin qubit encoded in two electrons in a GaAs double quantum dot. Starting from a set of numerically optimized control pulses [1], we employ an iterative tuning procedure based on measured error syndromes to remove systematic errors.Randomized benchmarking yields an average gate fidelity exceeding 98 % and a leakage rate into invalid states of 0.2 %. These gates exhibit a certain degree of resilience to both slow charge and nuclear spin fluctuations due to dynamical correction analogous to a spin echo. Furthermore, the numerical optimization minimizes the impact of fast charge noise. Both types of noise make relevant contributions to gate errors. The general approach is also adaptable to other qubit encodings and exchange based two-qubit gates [2].

[1]Pascal Cerfontaine, Tim Botzem, David P. DiVincenzo, and Hendrik Bluhm, Phys. Rev. Lett. **113**, 150501 (2014)
[2]Sebastian Mehl, Hendrik Bluhm, and David P. DiVincenzo, Phys. Rev. B **90**, 045404 (2014)