Characterization of a Room Temperature Two Electronic Spin Gate in Diamond

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Diamond is an exciting platform for quantum information as it hosts qubits that are highly coherent even at ambient conditions. So far high quality two qubit gates in diamond have been realized using relatively slow coherent control of nuclear spins. Alternatively, gates between multiple electronic (NV) spins have been demonstrated but require extensive numerical optimization to reach good fidelities. In particular, there is a lack of understanding of the different error sources that determine electronic two qubit gate fidelity.

Here, we design a fast, relatively simple entangling gate between NV spins in diamond. We describe a variety of challenges, namely charge state initialization fidelity, microwave crosstalk in the spectrally dense environment and interaction with the inherent nitrogen nuclear spins, that high quality control of this system poses. Experimentally, we study the effect of those error sources on the gate fidelity which allows to identify the mechanisms currently limiting the control quality of this multi qubit system.