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Error dynamics during coherent electron spin shuttling

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Abstract

Quantum information transport over micron to millimeter scale distances is critical for the operation of practical quantum processors based on spin qubits. One method of achieving long-range entanglement is by coherent electron spin shuttling through an array of silicon quantum dots. In order to execute high fidelity shuttling operations required to link millions of qubits on a processor, it is essential to understand the dynamics of qubit dephasing and relaxation during the shuttling process in order to mitigate noise sources before they cause errors. However, errors arising after implementing a large number of repeated shuttles are not yet well documented. We probe decay dynamics contributing to dephasing and relaxation of a singlet-triplet qubit during coherent spin shuttling over many N repeated shuttle operations. We find that losses are dominated by magnetic dephasing for small $N < 10^3$ and by incoherent shuttle errors for large $N > 10^3$. Additionally, we estimate a competitive shuttle error rate below 1×10^{-4} out to at least $N = 10^3$, representing an encouraging figure for future implementations of spin shuttling to entangle distant qubits.