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Weak measurement and quantum steering of spin qubits in silicon ANDREA MORELLO, JUHA MUHONEN[1], STEPHANIE SIMMONS[2], SOLOMON FREER, JUAN DEHOLLAIN, UNSW Australia, JEFFREY MCCALLUM, DAVID JAMIESON, Univ Melbourne, KOHEI ITOH, Keio University, ANDREW DZURAK, UNSW Australia — Single-shot, projective measurements have been demonstrated with very high fidelities on both the electron [1] and the nuclear [2] spin of single implanted phosphorus (^{31}P) donors in silicon. Here we present a series of experiments where the measurement strength is continousuly reduced, giving access to the regime of weak measurement of single spins.
For the electron qubit, the measurement strength is set by the measurement time compared to the spin-dependent tunneling time between the ^{31}P donor and a charge reservoir. For the nuclear qubit, the measurement strength is set by the rotation angle of an ESR pulse.
We have demonstrated quantum steering of the spin states, with curious and useful applications. We can improve the fidelity of electron qubit initialization by steering it towards the ground state, thus bypassing thermal effects on the initialization process. We can also accurately measure the electron-reservoir tunnel coupling, without the electron ever tunneling away from the ^{31}P atom. Finally, these techniques allow the study of weak values and Leggett-Garg inequalities.
[1] A. Morello et al., Nature 467, 687 (2010)
[2] J.J. Pla et al., Nature 496, 334 (2013)

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