Readout sweet spots for spin qubits with strong spin-orbit interaction

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Qubit readout schemes often deviate from ideal projective measurements, introducing critical issues that limit quantum computing performance [1, 2]. In this work [3], we model charge-sensing-based readout for semiconductor spin qubits in double quantum dots (see Fig. 1), and identify key error mechanisms caused by the back-action of the charge sensor [4]. We quantify how the sensor's charge noise, residual tunneling, and *g*-tensor modulation degrade readout fidelity, induce a mixed post-measurement state, and cause leakage from the computational subspace. For state-of-the-art systems with strong spin-orbit interaction and electrically tunable *g*-tensors [5], we identify a readout sweet spot, that is, a special magnetic field direction, shown in Fig. 2, where readout is optimized. Our framework provides a foundation for developing effective readout error mitigation strategies, with broad applications for optimizing readout performance for a variety of charge-sensing techniques, advancing quantum protocols, and improving adaptive circuits for error correction [6].

References

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Figures

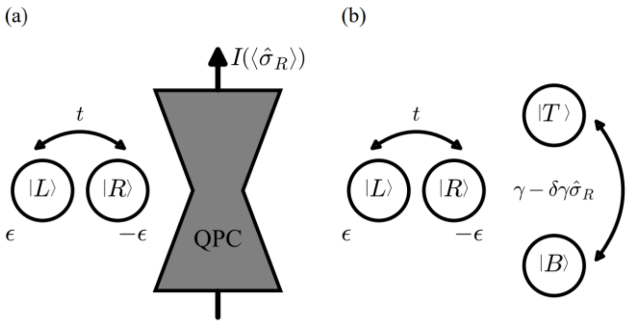

Figure 1: Model for charge sensing using a quantum point contact (QPC). (a) Schematic figure of the double quantum dot hosting a charge- or spin qubit next to the QPC. (b) The QPC is modelled as a second double quantum dot interacting with the qubit. Measurement of the qubit is achieved by subsequent measurements on the second double dot.

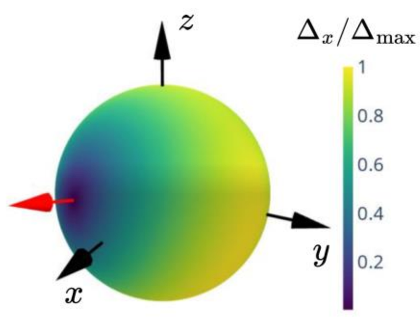

Figure 2: The dependence of the transversal component Δ_x of the QPC-induced modulation of the local Zeeman field on the external magnetic field direction. The red arrow indicates the sweet spot magnetic field direction where Δ_x is zero, and consequently leakage is minimal.