High Fidelity Gates For NV Electron and Nuclear Spin Qubits

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In this work, we discuss improvements in the fidelity of two qubit (electron-nuclear) NV spin qubit gates. In particular, for potential quantum computing scenarios using NV solid-state qubits, there are many open fundamental scientific problems including technical issues that need to be overcome on the way to applications. These include increasing the reliability of two-qubit gates, as well as spin contrast and scalability. We present a new quantum state tomography methodology leading to reaching 99.96 fidelities for ODMR detection and high spin contrast (50%) for electrical spin state detection at room temperature. The protocols are based upon Rabi oscillations density and matrix theory which we will present. We discuss also the improvements required in the diamond electronic transport characteristics for electrical detection of spin states in the quantum regime. We describe the challenges and main obstacles to using electrical readout in quantum computing.

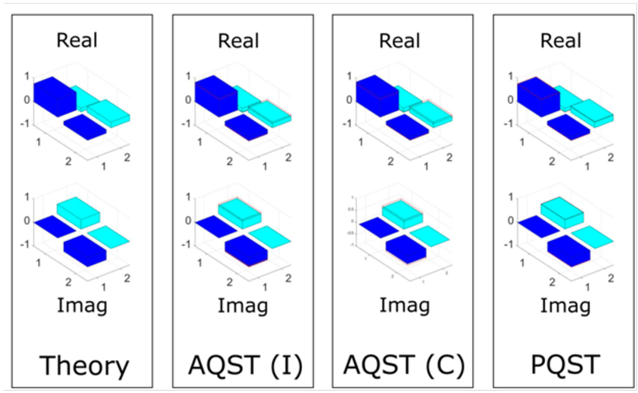

Figure 1: Comparison of the real and imaginary parts of the theoretical density operator with the experimentally determined density operators using Rabi Quantum State Tomography (RQST) for amplitudes (AQST) or phase (PQST). "AQST (I)" shows the density operator based on light intensity data. "AQST (C)" shows the density operator determined in amplitude tomography based on contrast data. Lastly, "PQST" shows the density operator calculated phase. The PQST for 14N nuclear spin read by NV electron spin reaches 99,96

References

[1] M Gulka, D Wirtitsch, V Ivády, J Vodnik, J Hruby, G Magchiels, E Bourgeois, A Gali, M Trupke and M Nesladek, Nat. Commun. **12**, 4421, DOI:10.1038/s41467-021-24494-x