Fast and high-fidelity dispersive readout of a spin qubit via squeezing and resonator nonlinearity

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We investigate dispersive measurement of an individual electron spin in a semiconductor double quantum dot that is coupled to a nonlinear microwave resonator [1,2]. By employing displaced squeezed vacuum states, we achieve rapid and high-fidelity readout for semiconductor spin qubits. Our findings reveal that the introduction of modest squeezing and mild nonlinearity can significantly improve both the signal-to-noise ratio (SNR) and the fidelity of the qubit-state readout. By properly matching the phases of squeezing, the nonlinear coupling coefficient, and the local oscillator, the optimal readout time can be reduced to the sub-microsecond range. For example, with currently accessible parameters with cavity leakage κ and qubit dispersive coupling χ_S in the same order, at about 0.15 MHz, utilizing a displaced squeezed vacuum state with 30 photons and a moderate squeezing parameter $r = 0.85$, along with a nonlinearity strength of $\lambda \sim -1.2\chi_S$, a readout fidelity of 98% can be attained within a readout time of around 0.6 ms. Our findings show the potential of improving spin qubit readout speed and fidelity by manipulating photon statistics of the probing light.

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References:

[1] Sub-microsecond high-fidelity dispersive readout of a spin qubit with squeezed photons, Chon Fai Kam and Xuedong Hu, arXiv:2312.10820.

[2] Fast and high-fidelity dispersive readout of a spin qubit via squeezing and resonator nonlinearity, Chon Fai Kam and Xuedong Hu, arXiv:2401.03617.