Cavity-enhanced single-shot readout of a quantum dot spin state within 3 nanoseconds

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The ability to perform a projective measurement of a quantum state in a single measurement iteration (single-shot readout) is an enabling technique in quantum technologies. Single-shot readout is necessary in quantum computation protocols for extracting information at the end of the computation, as well as error detection and correction as the quantum processor runs [1]. Achieving single-shot readout within the qubit dephasing time enables experiments such as measurement-based quantum feedback [2,3] and quantum trajectory tracking [4].

The spin states of optically active III-V semiconductor quantum dots (QDs) are a promising resource for quantum technologies; however single-shot readout has proven challenging due to low photon collection efficiencies and back-action induced by the readout laser. Of the small number of previous experiments to achieve single-shot readout of InAs QD spin states, the most rapid to date achieved a fidelity of 82% in a readout time of 800 ns [5], significantly longer than the maximum spin T_2^* times achieved to date (125 ns [6]).

Here we achieve single-shot readout of an InAs quantum dot spin state with a fidelity of 96% in only 3 nanoseconds, an improvement of more than two orders of magnitude and well within the achievable T_2^* time. Our approach uses a miniaturised Fabry-Perot microcavity to enhance the spin readout signal. Our work builds on the recent demonstration of an on-demand single-photon source with a record 57% efficiency using the same cavity platform [7]. The rapid readout we demonstrate opens up new possibilities for InAs QD spin states in quantum technologies.

Figures

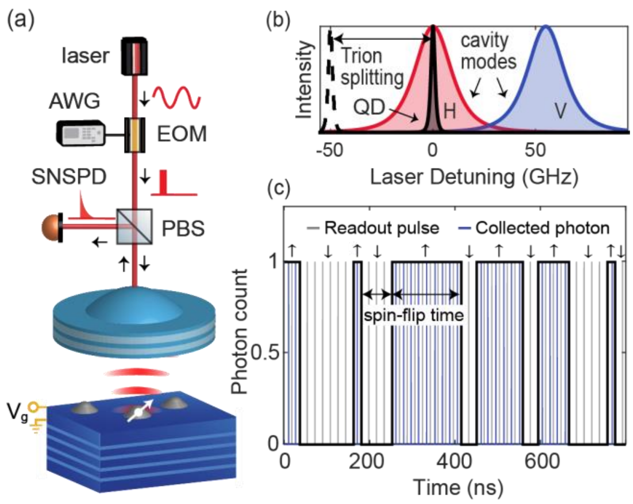

Figure 1: Tunable microcavity and single-shot readout. (a) Experimental setup. (b) Cavity enhancement of quantum dot emission. (c) Repeated single-shot readout experiments, showing quantum jumps in the QD spin state.

References

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