Abstract Submitted
for the DAMOP20 Meeting of
The American Physical Society

Background-Free State Detection of $^{88}Sr^{+}$ Optical Qubits COLIN BRUZEWICZ, JULES STUART, DAVID REENS, ROBERT NIFFENEGGER, ROBERT MCCONNELL, JOHN CHIAVERINI, JEREMY SAGE, MIT Lincoln Lab — State-dependent fluorescence detection schemes that rely on optical excitation and detection at the same wavelength are subject to undesirable background counts due to, for example, excitation light scattered by nearby optics. Here, we eliminate scattered light background counts for an optical $^{88}Sr^{+}$ qubit by implementing a two-step excitation protocol and detecting light at a wavelength separated by hundreds of nanometers from that of the excitation lasers. This technique uses the $4D_{3/2}$ and $5P_{1/2}$ levels to detect the $5S_{1/2}$ qubit state without populating the $4D_{5/2}$ qubit state. With increased laser intensity to quickly drive the dipole-forbidden $S_{1/2} \rightarrow D_{3/2}$ transition and two laser frequencies to address both ground state Zeeman sublevels, we achieve photon count rates that permit high-fidelity state detection and also demonstrate motional state cooling using this pathway. Additionally, this two-step readout scheme may find use in applications, such as in integrated photonic devices, where visible and NIR excitation light is preferred to the blue and UV light used in single-wavelength state detection.

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Date submitted: 31 Jan 2020 Electronic form version 1.4