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High Purity Single Photons Entangled with an Atomic Qubit[1]

KSENIA SOSNOVA, MARTIN LICHTMAN, ALLISON CARTER, CLAYTON CROCKER, SOPHIA SCARANO, CHRISTOPHER MONROE, Joint Quantum Institute and University of Maryland — Trapped ion quantum networks feature identical stationary qubits that can interact locally via phonons within ion-trap modules and remotely via photonic flying qubits that connect separate modules. The single-photon purity, and ion-photon entanglement fidelity are of crucial importance for such quantum information networks, but there is often a tradeoff between these attributes and the rate of heralded entanglement. We demonstrate a single-photon source based on single trapped $^{138}Ba^{+}$ ion subject to pulsed excitation, and we report a second-order coherence of $g^{(2)}(0) = (8.1 \pm 2.3) \times 10^{-5}$ without any background subtraction, and present results on the effect of integration time. Next, we show entanglement between the stationary ion spin qubit and flying photon polarization qubit and explore the errors due to polarization mixing at large collection solid angle in a free space system. We introduce spatial filtering of the emitted light to optimize the tradeoff between the photon generation rate and the entanglement fidelity. This technique improves the ion-photon entanglement fidelity from $F = 0.884(4)$ to $F = 0.930(4)$.

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