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Toward ion-photon entanglement with barium-138 ground state Zeeman levels[1] NATHAN KURZ, MATTHEW DIETRICH, GANG SHU, KATHERINE MITCHELL, BORIS BLINOV, University of Washington — Robust generation of entangled ion-photon and multi-ion states is a crucial step to many quantum information processing protocols [1]. Using single barium-138 ions in a linear Paul trap, we propose a qubit scheme using the m=+1/2 and m=-1/2 Zeeman sublevels of the $6S_{1/2}$ ground state. We estimate the lower bound of the coherence time of this qubit at 200 μs based on measurements on the $6S_{1/2} - 5D_{5/2}$ optical qubit at 1762 nm using a narrowband fiber laser at 1762 nm. Detection of the Zeeman qubit state can be performed by selectively shelving one of the Zeeman sublevels to the $5D_{5/2}$ level. A mode-locked Ti:Sapphire at 968 nm doubled to 493 nm on-resonance with the transition to $6P_{1/2}$ excites the ion, which subsequently emits a single photon whose polarization modes are entangled with the magnetic spin of the ion. Photonic qubit rotations are accomplished after the collection optics with waveplates, a polarizing beam splitter and photomultiplier tubes.

[1] R. Raussendorf and H. J. Briegel, PRL 86: 22, 5188-91 (2001).

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