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Two-Qubit Optical Gate in a Mixed-Species Trapped-Ion Quantum Processor COLIN BRUZEWICZ, JONATHON SEDLACEK, JULES STUART, ROBERT MCCONNELL, JEREMY SAGE, JOHN CHIAVERINI, MIT Lincoln Laboratory — Here we demonstrate an entangling Molmer-Sorensen (MS) gate between co-trapped $^{40}Ca^{+}$ and $^{88}Sr^{+}$ ions using electronic transitions to the ions metastable excited states. This inter-species quantum gate may find use in a large-scale trapped-ion processor where one atomic species is used for high-fidelity logic operations and the second auxiliary species is used for low crosstalk state readout and sympathetic motional cooling. The use of optical qubits in a $^{40}Ca^{+}$ and $^{88}Sr^{+}$ system is particularly appealing because the laser wavelengths that drive the MS interaction are in the visible portion of the spectrum. These wavelengths are compatible with low-loss photonic waveguides that can be integrated directly into the multi-layer structure of a microfabricated ion-trap-chip. As demonstrated previously in our group in a separate experiment, integrated waveguides can be used to route laser beams to the ion locations without the need for bulk free-space optics, potentially enabling more sophisticated ion-trapping geometries.

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