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Quantum Information Processing with Modular Networks[1] CLAYTON CROCKER, ISMAIL V. INLEK, DAVID HUCUL, KSENIA SOSNOVA, GRAHAME VITTORINI, CHRIS MONROE, Joint Quantum Institute, University of Maryland Department of Physics and National Institute of Standards and Technology, College Park, Maryland 20742 — Trapped atomic ions are qubit standards for the production of entangled states in quantum information science and metrology applications. Trapped ions can exhibit very long coherence times, external fields can drive strong local interactions via phonons, and remote qubits can be entangled via photons. Transferring quantum information across spatially separated ion trap modules for a scalable quantum network architecture relies on the juxtaposition of both phononic and photonic buses. We report the successful combination of these protocols within and between two ion trap modules on a unit structure of this architecture where the remote entanglement generation rate exceeds the experimentally measured decoherence rate. Additionally, we report an experimental implementation of a technique to maintain phase coherence between spatially and temporally distributed quantum gate operations, a crucial prerequisite for scalability. Finally, we discuss our progress towards addressing the issue of uncontrolled cross-talk between photonic qubits and memory qubits by implementing a second ion species, Barium, to generate the photonic link.

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