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Modular Entanglement of Trapped Ion Qubits Using both Phonons and Photons[1] ISMAIL INLEK, DAVID HUCUL, GRAHAME VITTORINI, CLAY CROCKER, Joint Quantum Institute, University of Maryland Department of Physics and National Institute of Standards and Technology, College Park, Maryland 20742, SUSAN CLARK, Sandia National Laboratories, SHANTANU DEBNATH, 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 standard qubits for the production of entangled states for applications in quantum information science, with their long coherence times and local Coulomb interactions that can be gated by external fields. However, scaling this system to large dimensions may require the addition of other interfaces such as photonic quantum information transfer. We report the experimental realization of gates combining remote and local entanglement protocols between three ions in two separate traps. Using a two-photon interference protocol with fast imaging optics, we demonstrate 4.25 Hz entangling rates between distant trapped ion qubits. Importantly, the remote and local ion entanglement generation rate is much faster than the observed entangled state decoherence rate, which is key to scaling to larger quantum networks.

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