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Photonic integration for trapped-ion quantum information science

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A major architecture for large-scale quantum computing with trapped ions relies on individual computational nodes that are linked via quantum networking. This multi-node architecture would also benefit hybrid networks between trapped ions and other quantum systems. Quantum networks of practical scales will require modularization of the quantum control hardware and reduction of the equipment and alignment overhead. To realize this vision, we are developing new methods of integrating light delivery and collection into photonic waveguides on-chip. To achieve qubit array addressing without free-space optics, we are integrating emission structures for light delivery at colors and polarizations necessary for ion cooling and qubit manipulation. By collecting emitted single photons into waveguides and combining them on a beamsplitter, ion qubits can be remotely entangled via heralded photon coincidence using solely integrated optical elements. This entanglement between nodes would allow many chains of trapped ions, functioning as small quantum computers, to be coherently interconnected via teleported gates. Thus, chip-integration of photonic elements can pave the way towards distributed quantum computing and quantum networking with trapped ions.

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