Trapped Ion Quantum Networks

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Abstract: We describe the use of a photonic coupling between remote trapped ions for applications in quantum communication and quantum computing.

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Trapped atomic ions are among the most promising candidates for quantum information processing, with particular internal electronic states of each ion storing a single quantum bit (qubit) of information [1]. Such states enjoy extremely long-lived coherence times, and they can also be measured with near-perfect efficiency. Small numbers of nearby atomic ions can be deterministically entangled through their Coulomb interaction and a suitable interaction with laser beams [1]. Alternatively, probabilistic entanglement over remote distances can be accomplished through a purely photonic coupling between trapped ions [2,3]. This latter coupling will be described in some detail, including the recent observation of a Bell inequality violation with remotely-located atomic qubits [4]. Future experiments in the networking of trapped ion quantum information may involve both Coulomb and photonic coupling of trapped ions in order to generate truly large-scale entangled quantum states. Promising applications in this area include quantum repeaters and distributed quantum computing [3,5]. I will discuss several options for networking trapped ion qubits, along with state-of-the-art experimental progress.

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