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Quantum Networking with Atomic Ensembles

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Quantum communication networks enable secure transmission of information between remote sites. However, at present, photon losses in the optical fiber limit communication distances to less than 150 kilometers. The quantum repeater idea allows extension of these distances. In practice, it involves the ability to store quantum information for a long time in atomic systems and coherently transfer quantum states between matter and light. Previously known schemes involved atomic Raman transitions in the UV or near-infrared and suffered from severe loss in optical fiber that precluded long-distance quantum communication. In this work a practical quantum telecommunication scheme based on cascade atomic transitions is proposed, with particular reference to cold alkali metal ensembles. Within this proposal, essential building blocks for a quantum network architecture are demonstrated experimentally, including storage and retrieval of single photons transmitted between remote quantum memories, collapses and revivals of quantum memories, deterministic generation of single photons via conditional quantum evolution, quantum state transfer between atomic and photonic qubits, entanglement of atomic and photonic qubits, entanglement of remote atomic qubits, and entanglement of a pair of 1530 nm and 780 nm photons. These results pave the way for construction of a realistic quantum repeater for long distance quantum communication.

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