

Integrated, Multiplexed Quantum Memories for Quantum Communication

The distribution of entanglement between the nodes of a quantum network will allow new advances e.g. in long-distance quantum communication, distributed quantum computing and quantum sensing. On the ground, quantum information can be distributed across the nodes using single photons at telecommunication wavelengths traveling in optical fibres, where quantum repeaters can be used to bridge distances much longer than the fibre attenuation length. The nodes of this quantum network are physical material systems that should efficiently interact with quantum light, exchange entanglement with photons (ideally at telecommunication wavelengths) and serve as a quantum memory, allowing long-lived and faithful storage of quantum information. In addition, for efficient distribution of entanglement, the nodes should allow multiplexed operation and ideally enable quantum processing capabilities between stored qubits. In this talk I will outline our research on solid-state quantum repeater nodes. We use cryogenically cooled rare-earth ion-doped solids, that store quantum information as a delocalised excitation of the ions. I will describe our latest results in realising entanglement between a telecom photon and a spin-wave, thereby realising the elementary unit of a quantum repeater. The solid-state nature of these memories makes them suitable platform for the realisation of integrated photonic structures: I will outline our latest result with storage of entanglement in a fibre-coupled quantum memory. Finally, I will report a recent experiment demonstrating entanglement between remote multiplexed solid-state quantum memories, heralded by a telecom photon. These results will lead the way to scaling up quantum network links across a metropolitan area.