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Single 40Ca+ ion-based quantum repeater cell - experimental demonstration and perspectives

The quantum repeater cell according to [1] is a basic building block for a quantum repeater [2], that allows one to overcome the distance limitations of direct transmission in a future quantum internet [3]. We demonstrate the implementation of a quantum repeater cell based on two free-space coupled 40Ca+ ions trapped in a single linear Paul trap. Photons emitted by each ion create ion-photon entanglement [4] and are coupled to two separate single-mode fibers. The ion-photon entanglement is generated in an asynchronous manner by driving one ion independently of the other. Distant photon-photon entanglement is finally obtained through entanglement swapping [6], by applying a Mølmer–Sørensen quantum gate [5] between the ions and subsequently projecting the two ions. We characterize the asynchronously generated ion-photon entanglement and the photon-photon entanglement achieved by the protocol and discuss the scaling of this implementation. Furthermore, we present the status of a new ion trap setup with integrated cavity, designed to increase the probability and rate of photon emission. Finally, we discuss the use of short excitation pulses to increase the photon purity for its use in a photonic Bell state measurement.

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