Matter-Matter Entanglement for Quantum Communication

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The distribution of entanglement between different parties enables quantum communication protocols, such as quantum key distribution or teleportation. Furthermore, control of entanglement between material systems is an essential capability for scalable architectures. This talk will focus on the experimental generation of such entanglement in different setups, in the regime of single photons or in the regime of continuous variables.

The first part will review experiments done recently in the single excitation regime. First, by following the seminal paper of Duan, Lukin, Cirac and Zoller (*DLCZ*) [1], entanglement between single collective excitations stored in two remote atomic ensembles can be generated. In the *DLCZ* protocol, entanglement is created in a probabilistic but heralded way from quantum interference in the measurement process. The detection of a photon from one or the other atomic ensemble in an indistinguishable fashion results in an entangled state with one collective spin excitation shared coherently [2]. This entanglement has been used for the initial implementation of functional quantum nodes for polarization entanglement distribution involving the asynchronous preparation of two parallel pairs of entangled atomic ensembles [3]. Swapping of entanglement between entangled matter systems has also been investigated [4]. In this regime, a second way to generate entanglement between two atomic ensembles is to map into an entangled state of light [5]. A single photon is first split into two modes to generate photonic entanglement, which is then mapped to an entangled matter state in two ensembles by EIT. On demand, the stored entanglement is converted back into entangled photonic modes.

The two previous methods involve single excitations and single photons. An active direction concerns also the storage of noncalssical states in the regime of continuous variables. The talk will then focus on works recently developed, based on storage and retrieval of continuous variable of light into atomic ensembles [6,7]. For a vapor of cesium atoms, using EIT and Zeeman coherences, the case where a tunable single-sideband is stored independently of the other one to the case where the two symmetrical sidebands are stored using the same transparency window are compared. The optimal response frequency of the medium for storage can be adapted to the frequency to be stored by changing the control magnetic eld, keeping the EIT window rather narrow. Excess noise associated with spontaneous emission and spin relaxation is small, and quantum performance of the memory can be characterized by measuring the signal transfer

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coefficient T and the conditional variance V and using the T-V criterion as a state independent benchmark. To generate entanglement between two ensembles in this regime, I will describe the squeezing source recently built [8] which enables to generate continuous variable entanglement between lateral sidebands. The principle of the on-going experiment will be described.

References

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