Long-lived non-classical correlations for scalable quantum repeaters at room temperature

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The efficiency of long-distance quantum communication via direct optical links is strongly limited by transmission loss. A prospective solution is to establish a network of quantum repeaters (QRs) to distribute entanglement, which can be used for quantum communication. For practical implementation of such networks, the QR architecture must be easily scalable; hence, favouring systems which do not require cooling. However, the use of room-temperature devices is limited by either short memory lifetimes or inability to drive coherent interaction above cryogenic temperatures.

We work towards a heralded single-photon source from a room-temperature atomic vapour based on the DLCZ protocol for QRs [1]. In this scheme, the detection of a photon emitted from an atomic ensemble through spontaneous Raman scattering heralds the creation of a collective atomic excitation. By applying a retrieval light pulse, the collective excitation can be read out in the form of a single photon at a desired moment in time. This herald-retrieve scheme has shown remarkable capability in cold ensembles, but the performance of warm ensembles has so far been hampered by dephasing due to atomic motion.

We present our latest results [2] of efficient heralding and readout of single collective excitations created in a warm caesium vapour without buffer gas contained in an anti-relaxation-coated glass cell. To extend the memory lifetime beyond the dephasing time induced by atomic motion, we implement the scheme proposed in ref. [3] where the atom-light coupling is averaged over atomic motion to create a collective excitation symmetric in all atoms of the ensemble. We achieve a memory lifetime of 0.27 ± 0.04 ms, which is two orders of magnitude larger than for previous warm vapour sources. Moreover, we experimentally verify non-classicality of the light-matter correlations by observing a violation of the Cauchy-Schwarz inequality with $\mathrm{R} = 1.4\pm0.1$. However, the fidelity of single-photon readout is compromised by an intrinsic four-wave-mixing noise process. We propose modifications to the scheme, which prospectively prohibit four-wave mixing.

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