DAMOP13-2013-000270

Abstract for an Invited Paper
for the DAMOP13 Meeting of
the American Physical Society

Atom-photon entanglement as a resource for remote entanglement of quantum memories and quantum teleportation

WENJAMIN ROSENFELD, LMU Munich and Max-Planck-Institute of Quantum Optics

Interfacing of atomic systems with photonic communication channels will be the key element in future quantum information processing and communication tasks. In this context, atom-photon entanglement has shown a high potential. Here we present two experiments demonstrating its capabilities: entangling two atomic quantum memories at remote locations and teleportation of the polarization state of a photon onto a memory. We apply the entanglement swapping scheme for generating entanglement between two widely separated memories. It starts by entangling each quantum memory with a photon, which can be conveniently transported via optical fibers. A Bell-state measurement on photons then projects the atomic system onto an entangled state. In our experiment we work with single Rb-87 atoms which are optically trapped in two independent setups separated by 20 meters. By optically exciting the atoms we generate single photons whose polarization is entangled with the atomic spin. Two-photon interference allows us to detect two out of four Bell-states thereby heralding the entanglement of the two atoms. Correlation measurements on the atomic spins reveals a fidelity of the entangled atom-atom state of 0.81 [1]. In the second experiment we performed quantum teleportation of the polarization state of a weak coherent pulse onto the quantum memory. Here we use the same setup where on one side an atom is entangled with a photon. On the other side a weak laser pulse of a certain polarization is prepared, whose spectral and temporal parameters are matched to the single photon emitted by the atom. Again, by means of two-photon interference a Bell-state measurement is performed which enables teleportation of the initially prepared state onto the atom. By performing state tomography we extract the fidelity of the teleported state of 0.82 which is mainly limited by Poissonian photon statistics of the laser pulse.

[1] J. Hofmann, M. Krug, N. Ortegel, L. Gérard, M. Weber, W. Rosenfeld, H. Weinfurter, "Heralded entanglement between widely separated atoms," Science **337**, 72 (2012).