Long-distance atom-photon entanglement and its coherence properties

H. WEINFURTER, M. WEBER, J. VOLZ, W. ROSENFELD, M. KRUG, F. HOCKE, F. HENKEL, (1) SEKTION PHYSIK, LUDWIG-MAXIMILIANS-UNIVERSITY, D-80799 MUNICH, GERMANY COLLABORATION, (2) MAX-PLANCK-INSTITUTE FOR QUANTUM OPTICS, D-85748 GARCHING, GERMANY COLLABORATION — The distribution of entanglement between quantum memories at remote locations is one major challenge for the first demonstration of a quantum repeater. Entanglement between matter and light [1] is crucial for achieving this task. Here we report the observation of entanglement between a single trapped atom and a single photon, separated 300 m via an optical fiber. The entanglement is verified by appropriate correlation measurements of the atom-photon pair after communicating the photon through the fiber. In addition we measured the temporal evolution of the atomic density matrix after projecting the atom-photon pair via a state measurement of the photon onto a well defined atomic spin state. We find that the atomic Zeeman qubit decoheres after 100 $\mu$s. Our results represent important steps towards the realization of entanglement between single neutral atoms at distances of several 100 m.