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Entanglement of 3000 atoms by detecting one photon

VLADAN VULETIC, MIT

Quantum-mechanically correlated (entangled) states of many particles are of interest in quantum information, quantum computing and quantum metrology. In particular, entangled states of many particles can be used to overcome limits on measurements performed with ensembles of independent atoms (standard quantum limit). Metrologically useful entangled states of large atomic ensembles (spin squeezed states) have been experimentally realized. These states display Gaussian spin distribution functions with a non-negative Wigner quasiprobability distribution function. We report the generation of entanglement in a large atomic ensemble via an interaction with a very weak laser pulse; remarkably, the detection of a single photon prepares several thousand atoms in an entangled state. We reconstruct a negative-valued Wigner function, and verify an entanglement depth (the minimum number of mutually entangled atoms) that comprises 90% of the atomic ensemble containing 3100 atoms. Further technical improvement should allow the generation of more complex Schrödinger cat states, and of states the overcome the standard quantum limit.