Homodyne Tomography of a Single Photon Retrieved on Demand from a Cavity-Enhanced Cold Atom Memory

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Reference:
Bimbard, R. Boddeda, N. Vitrant, A. Grankin, V. Parigi, J. Stanojevic, A. Ourjoumtsev, P. Grangier, Homodyne Tomography of a Single Photon Retrieved on Demand from a Cavity-Enhanced Cold Atom Memory, PHYSICAL REVIEW LETTERS 112:3, 033601 (2014)
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We experimentally demonstrate that a nonclassical state prepared in an atomic memory can be efficiently transferred to a single mode of free-propagating light. By retrieving on demand a single excitation from a cold atomic gas, we realize an efficient source of single photons prepared in a pure, fully controlled quantum state. We characterize this source using two detection methods, one based on photon-counting analysis and the second using homodyne tomography to reconstruct the density matrix and Wigner function of the state. The latter technique allows us to completely determine the mode of the retrieved photon in its fine phase and amplitude details and demonstrate its nonclassical field statistics by observing a negative Wigner function. We measure a photon retrieval efficiency up to 82% and an atomic memory coherence time of 900 ns. This setup is very well suited to study interactions between atomic excitations and use them in order to create and manipulate more sophisticated quantum states of light with a high degree of experimental control.

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