Observation of light quantum jumps and time-resolved reconstruction of field states in a cavity

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After a general review of recent developments in Cavity Quantum Electrodynamics, I will focus on experiments performed at ENS on microwave fields trapped during a few tenths of a second in a very high Q superconducting cavity [1].

Circular Rydberg atoms crossing the cavity one at a time are used to count trapped photons in a quantum non-demolition (QND) way, projecting in the process the field into a Fock state containing a well-defined number of light quanta [2]. The subsequent evolution of these states induced by cavity damping exhibits photon number quantum jumps observed on single field trajectories [3]. The usual exponential decay of the field energy is recovered by averaging over these trajectories, whose statistical analyzis yields a direct measurement of all the damping rates of the field master equation [4].

By using atoms to perform QND measurements on an ensemble of cavity fields prepared in the same state, we fully reconstruct this state and its Wigner function [5]. The method is applied to coherent states whose Wigner function is gaussian and to non-classical Fock and Schrödinger cat states exhibiting Wigner functions with striking non-gaussian features presenting negative values. By following the time-evolution of the reconstructed field states, we observe the progressive disappearance of these non-classical features and realize actual 'movies' of the decoherence phenomenon.

These studies in which photons are trapped and manipulated non-destructively by atomic beams can be viewed as the counterpart of ion trap experiments, in which atoms are localized in space and interrogated by laser beams. I will conclude by briefly discussing future projects generalizing these photon trap studies to two cavities and implementing quantum feedback methods to lenghten decoherence times in cavity QED experiments.

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[3] S. Gleyzes *et al*, Nature **446**, 297 (2007).
[4] J. Bernu, C. Guerlin *et al*, to be published.
[5] S. Deléglise, I. Dotsenko, C. Sayrin *et al*, to be published.