Single photon sources based on weakly nonlinear systems

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Following the progress in nanofabrication, several types of nanostructures have been recently proposed, in which photonic modes coupled to other degrees of freedom faithfully reproducing the physics of model Hamiltonians interacting with a dissipative environment. Examples are optical resonators coupled to semiconductor quantum dots, optomechanical systems, or superconducting circuits. These systems hold promise as driven-dissipative quantum simulators, able to generate nonclassical states of light and matter. Common schemes however, rely on a regime of strong light-matter coupling (i.e. strong optical nonlinearities), which, in most cases, still lies way beyond the current state of the art. The question is then, whether nonclassical states can be generated also in presence of the weak optical nonlinearities found in systems that are far more common, integrable and scalable.

The Unconventional Photon Blockade (UPB) exploits quantum interferences to produce a strongly antibunched output in a weakly nonlinear system. This mechanism was originally proposed in a system consisting of a pair of coherently coupled and Kerr-nonlinear cavities where one of them is driven by a classical source [1, 2]. It was then extended to Jaynes-Cummings, optomechanical or bimodal cavity systems and would be feasible in superconducting circuits or coupled microcavities. Crucially, the UBP was shown to match with Silicon photonic crystal cavities parameters, with the requirement of an ultra-low input power and could therefore provide a new class of highly integrable passive single photon source. However, the coherent mode coupling of magnitude J imposes a detrimental oscillation of the delayed second order correlation function $g^{(2)}(\tau)$ about 1, on a timescale 1/J. This time frame turns out to be much smaller than the photon lifetime under the required optimal antibunching conditions. Therefore, the standard schemes for the UPB are not directly compatible with pulsed excitation and the emission statistics turns out to be even slightly super-Poissonian over one pulse.

In this talk, we review the UPB mechanism, discuss the various systems in which it can be realized and present our latest achievements in the theoretical analysis of the effect. In particular, we show how time-gating the output can isolate the sub-poissonian part of the emitted light in the UPB scheme [3]. In addition, we propose a novel configuration, based on dissipatively coupled cavities, leading to a single photon emission under pulsed excitation with no need for additional postprocessing (see Fig1).

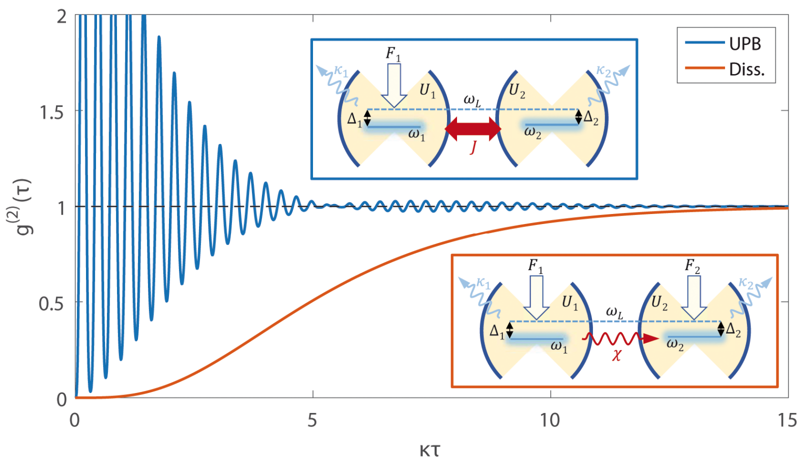

Fig.1: Comparison between the delayed second order coherence function of the UPB (red line and frames) and the dissipative schemes (blue line and frame) demonstrating the compatibility with pulsed excitation in the latter case.

[1] T. C. H. Liew and V. Savona, Phys. Rev. Lett. **104**, 183601 (2010); S. Ferretti, D. Gerace and V. Savona, New J. Phys. **15**, 025012 (2013);
[2] H. Flayac and V. Savona, Phys. Rev. A **88**, 033836 (2013).
[3] H. Flayac, D. Gerace and V. Savona, Sci. Rep **5**, 11223 (2015).
[4] H. Flayac and V. Savona, arXiv:1512.05537 (2015).