Cavity enhanced light-matter interactions and their use for non-classical light generation

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This talk will first provide an overview of recent experimental developments in cavity enhanced light-matter interactions in cavities of assorted sizes. Following the introduction, I will focus on our latest work exploring the use of a single quantum emitter coupled to a cavity as a photon number filter.

An individual two-level quantum emitter strongly coupled to a cavity can produce non-classical light by filtering the input stream of photons coming from a classical coherent light source through a mechanism described as ‘photon blockade’. Recent proposals have extended the concept of photon blockade from single photons to two-photon Fock state generation by coupling the probe laser to the second manifold of the Jaynes-Cummings ladder via a two-photon transition. This approach can be further generalized to create third- and higher-order photon states inside the cavity through multi-photon transitions to the corresponding manifold (Fig. 1 (a)). Following our proposal, we report the probing of these multi-photon transitions into the higher manifolds of the Jaynes-Cummings ladder of a strongly coupled quantum dot–photonic crystal nanocavity system by measuring the third-order autocorrelation function ($g^{(3)}(\tau_1, \tau_2)$) of a probe laser transmitted through such a system. We observe bunching in $g^{(3)}$ for transmitted photons when the probe laser is resonant with the third manifold and anti-bunching when the probe laser is tuned away from resonance. We contrast the value of $g^{(3)}(0,0)$ with the conventionally used $g^{(2)}(0)$ and demonstrate that in addition to being necessary for detection of two-photon states emitted by a low-intensity source, $g^{(3)}$ provides a more clear indication of the non-classical character of a light source, as distinguishable from coherent light. I will also present preliminary data that demonstrates bunching in the fourth-order autocorrelation function $g^{(4)}(\tau_1, \tau_2, \tau_3)$ as the first step toward detecting three-photon states.

Fig. 1: (a) Energy diagram showing the spacings between the levels of a system consisting of a two-level quantum emitter strongly coupled to a cavity. (b) The third-order temporal auto-correlation function $g^{(3)}(\tau_1, \tau_2)$ and (c) the fourth-order temporal auto-correlation function $g^{(4)}(\tau_1, \tau_2, \tau_3)$ observed in the photons transmitted through a resonantly probed photonic-crystal cavity containing a strongly coupled quantum dot.