Engineering Photon Sources With Interacting Quantum Emitters

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Quantum emitters, such as quantum dots and organic molecules, have an extremely narrow emission line at cryogenic temperatures and emit single photons when they are isolated [1]. Additionally, the interaction between quantum emitters leads to the formation of superradiant and subradiant states [2]. Superradiant states are characterized by a better coupling to light than an isolated emitter, which might be used to design faster photon sources. In contrast, subradiant states couple worse to light and have a larger lifetime, with possible applications in quantum information storage.

To better characterize the possibilities that these cooperative effects introduce to manipulate quantum properties of light for quantum technologies, we perform a detailed theoretical analysis of the intensity correlation of the photons emitted from two interacting emitters.

First, we study the color-blind intensity correlation $g^{(2)}(0)$, which measures the correlation between all the photons emitted from the system. We find that $g^{(2)}(0)$ can be tailored from strong antibunching, when the laser is tuned resonantly tuned to the superradiant state $|\Lambda_-\rangle$ (blue line in Fig. 1a), to strong bunching, when the laser is tuned to the two-photon resonance (red line), which allows for a large control of the quantum properties of the emitted photons. Interestingly, $g^{(2)}(0)$ shows a complex behaviour when the laser is tuned to the subradiant state $|\Lambda_+\rangle$ (green line in Fig. 1a), with the possibility of emitting both bunched and antibunched light depending on the laser intensity.

Moreover, we also analyse the frequency-resolved intensity correlation (FRIC) $g^{(2)}(\omega_1,\omega_2;0)$, which measures the correlation between pairs of photons of specific frequencies. The dependence of $g^{(2)}(\omega_1,\omega_2;0)$ on ω_1 and ω_2 is frequently analysed using 2D maps, as the one depicted in Fig. 1b. These maps are very promising characterization tools that unveil complex emission processes, such as two-photon emission transitions through virtual states [3]. In summary, we demonstrate that the statistics of light emitted from interacting emitters can be widely tailored and its characterization can unveil complex emission processes in this system.

References

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Figures

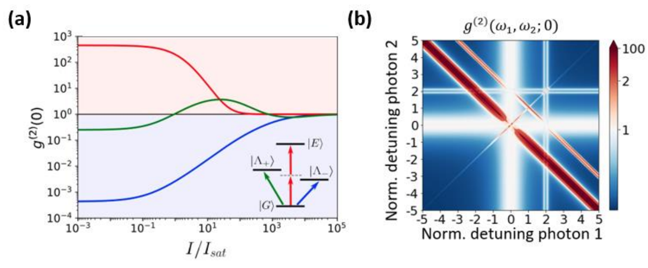

Figure 1: (a) $g^{(2)}(0)$ vs. laser intensity I, for the different laser detunings depicted in the inset. **(b)** FRIC map when the laser is tuned resonantly to the subradiant state $|\Lambda_-\rangle$ and the laser intensity is fixed at 50 times the saturation intensity I_{sat} of the single emitter.