Cavity-assisted generation of steady-state entanglement between non-identical quantum emitters

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Common wisdom suggests that, in order to entangle two quantum emitters, it is desirable that these have identical natural frequencies, since this facilitates cross talk between them and enables the type of collective dynamics that leads to entanglement [1]. However, the fabrication of quantum emitters with identical properties is a significant challenge in solid state physics.

In this work, we show that the condition of identical transition frequencies can be completely relaxed and that one can achieve maximum values of steady-state entanglement between non-identical quantum emitters by driving the two-photon resonance of the composite system. When the two emitters are interacting, this driving enables coherent two-photon Rabi oscillations between the ground and the doubly-excited state; this resonance has been exploited, e.g., to estimate interaction strengths and inter-molecular distances between molecules at the nanometer scale [2]. Under a strong two-photon drive, the emitters can be dressed with photon pairs from the laser, developing a rich family of energy levels that translate into a complex structure in the spectrum of resonance fluorescence [3].

By coupling the dressed system to a cavity in the bad cavity limit, new processes among the two-photon dressed energy levels can be engineered. By placing particular dressed-state transitions in resonance with the cavity, these novel decay processes can stabilize the system into a highly entangled state. Since the energy of the dressed states can be tuned through the Rabi frequency of the drive, the system can be optically tuned in and out of these resonances, so that entanglement can be optically controlled. We also show that the stabilization of entanglement translates into particular features in the quantum optical properties of the light emitted by the system at frequencies that are well detuned from the drive, allowing to isolate the optical signatures of entanglement by simple spectral filtering.

Notably, we show that, even when the interaction between emitters is weak or non-existing, driving at the two-photon resonance can also lead to stabilization of maximally entangled state if the Purcell enhancement provided by the cavity is high enough.

References

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