Quantum feedback in quantum dot - waveguide structures: Control of entanglement, emission statistics and dephasing

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Quantum feedback control of photonic structures can be based on measurements by using a classical sensor or based on coherent interactions using a quantum system as controller. In this talk, we develop the theory of a coherent feedback control scheme for photonic structures based on waveguides, cavities and semiconductor quantum dots (QD) as active systems [1]. Due to the waveguide geometry, the control scheme intrinsically contains time delay [2]. It can be used to stabilize entangled states in nano-cavities [3] and to steer the emission statistics / dephasing of quantum dots [4].
As a typical example, we discuss the photon emission-statistics of a two level QD: Without control, for π-pulse excitation, i.e. full inversion, the QD system basically acts as a single photon source. Contrary, increasing the pulse-area such that the pulse induces a full Rabi-oscillation, a two-photon emission process is more probable than a single photon [5]. In Fig. 1(a), we propose a scheme for time delayed quantum feedback of a QD in a semi-infinite waveguide to choose preferably single or two-photon emission induced by a 2π-pulse excitation. Our findings suggest quantum interference induced by the QD mirror image as an additional control parameter to either enhance or suppress the 2π-pulse triggered one/two-photon emission. Figs. 1(b)-(d) show the photon probability $p(n)$ for different feedback regimes in particular for destructive/constructive interference.

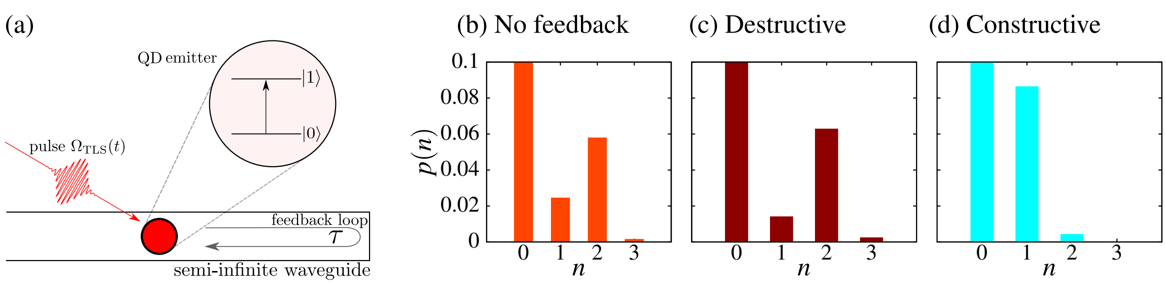

Figure 1: (a) 2π pulse excitation: A two-level QD placed inside a semi-infinite waveguide (ground state $|0\rangle$, excited state $|1\rangle$). Due to radiative decay, photons are emitted into the waveguide. Feedback occurs with time delay τ. This non-Markovian quantum feedback is essential for the control of the one-photon versus the two-photon probability. Photon probability distribution $p(n)$ for n photons: (b) Benchmark with Ref. [5] for the case without feedback. (c) Destructive feedback: $p(1)$ decreases by a factor of $1/2$ and $p(2)$ slightly increases. (d) Constructive feedback: Single photon emission dominates over two-photon emission.

References

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