Frequency Filtered Photon-Correlations

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Fluorescence and correlation filtering is a field with a rich history and, with the advent of quantum dots, continues to be studied. In this work we develop an efficient theoretical approach to better filter fluorescence from a driven system. To demonstrate this, we model a resonantly driven two-level system coupled as a cascaded system into an array of tunable single-mode filter cavities. This allows us to derive a set of moment equations for the two-level system and cavity mode operators, building upon the uncoupled Maxwell-Bloch equations:

$$\frac{\mathrm{d}}{\mathrm{d}t}\langle \hat{\boldsymbol{\sigma}} \rangle = \boldsymbol{M}\langle \hat{\boldsymbol{\sigma}} \rangle + \boldsymbol{b}, \tag{1}$$

where $\langle \hat{\boldsymbol{\sigma}} \rangle$ is the set of Pauli operator expectation values, $\langle \hat{\sigma}_{\pm} \rangle$ and $\langle \hat{\sigma}_{z} \rangle$, $\boldsymbol{M}$ is a matrix governing the evolution of the operator moments, and $\boldsymbol{b}$ is the non-homogeneous vector establishing a non-trivial steady state. The Pauli operator moments act as the progenitor source terms for all of the system's dynamics, and feed in to the higher order moments, as depicted in Fig. **??**, where $\hat{a}_j$ and $\hat{a}_j^{\dagger}$ are the photon annihilation and creation operators for the j^{th} filter mode.

In this work we present a novel and improved theoretical model for calculating frequency filtered photon correlations. We achieve this by coupling the output of a source system into an array of single-mode cavities, each with a slightly different resonance frequency, with Hamiltonian

$$H = H_{\mathrm{source}} + \hbar \sum_{j=-N}^{N} \omega_j f_j^{\dagger} f_j + \frac{i\hbar}{2}\left(\mathcal{E}_j^{*} f_j s^{\dagger} - \mathcal{E}_j f_j^{\dagger} s \right), \tag{2}$$

where H_{source} is the Hamiltonian of the source system with decay operator s, f_j is the photon annihilation operator for the j^{th} mode, $\omega_j = \omega_0 + j\delta\omega$ is the detuning of the j^{th} mode from the central frequency with spacing $\delta\omega$, and $\mathcal{E}_j$ is the cascaded systems coupling.