HUNTING FOR PHOTON CORRELATIONS

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Recently, frequency filtered correlations of two-level atoms have had a surge in interest [1, 2, 3]. Of particular interest is the effect that frequency filtering has on the resulting photon correlations. To investigate this effect, we model the resonantly two-level atom in a rotating frame, with master equation

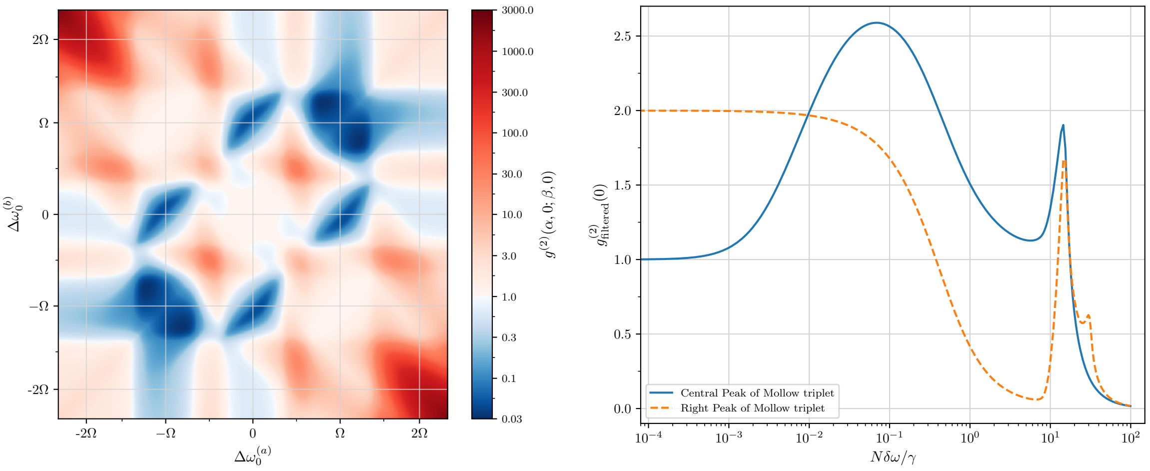
$$\frac{\mathrm{d}\hat{\rho}}{\mathrm{d}t} = -i\frac{\Omega}{2}[\hat{\sigma}_{+} + \hat{\sigma}_{-}, \hat{\rho}] + \frac{\gamma}{2}\left(2\hat{\sigma}_{-}\hat{\rho}\hat{\sigma}_{+} - \hat{\sigma}_{+}\hat{\sigma}_{-}\hat{\rho} - \hat{\rho}\hat{\sigma}_{+}\hat{\sigma}_{-}\hat{\rho}\right),$$

where Ω is the strength of the coherent driving laser, and γ is the atomic decay rate. Using cascaded open quantum systems theory [4], we cascade the atomic fluorescence into two multi-mode array filters. Using the quantum regression equations, we then calculate the *normalised frequency-filtered cross-correlation function*:

$$g^{(2)}(\alpha, 0; \beta, \tau) = \frac{\langle \hat{A}^{\dagger}(0)\hat{B}^{\dagger}\hat{B}(\tau)\hat{A}(0)\rangle_{ss}}{\langle \hat{A}^{\dagger}\hat{A}\rangle_{ss}\langle \hat{B}^{\dagger}\hat{B}\rangle_{ss}},$$

where α and β are the central resonance frequencies of filters A and B, respectively. By coupling the fluorescence into the multi-mode array filter, we achieve much better frequency isolation than a standard single-mode Lorentzian filter, and thus can measure correlations not seen before.

The strongly driven two-level atom has a rich history, and originally provided one of the first demonstrations of photon antibunching, where photons are emitted individually. Correlations of photons from each of the frequency components of the strongly driven have also been well studied [5]. In this work, then, we will use investigate regions *outside* of the three peaks, where a rich landscape of photon correlations will be revealed, as in Fig. 1a. We will also investigate the effect that frequency filtering has on the photon correlations. In Fig. 1b we see that nature of the filtered correlations change drastically as the filter halfwidth decreases [6].



(a) Initial value of the frequency-filtered cross-correlation function.

(b) Multi-mode $N = 10$ with $\kappa = \gamma, \delta\omega = 0.8\gamma$.

Figure 1: Initial cross-correlation values for different frequency detunings of filters A and B (a), and initial value of the frequency filtered auto-correlation function ($\alpha = \beta$) for decreasing filter halfwidth (b). In (a): red corresponds to photon bunching, $g^{(2)}(0) > 1$; white corresponds to second-order coherence, $g^{(2)}(0) = 1$; and blue corresponds to antibunching, $g^{(2)}(0) < 1$.

References

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