Two-photon correlations and HOM visibility from an imperfect single-photon source

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We study the two-photon correlations of an emitter based single-photon source in the realistic scenario where the drive field may leak into the detection path [1]. We find that the pulse length of the input field strongly influences the impurity of the single-photon source. In particular, the second-order correlation function $g^{(2)}$ reaches a minimum for a certain pulse length, which represents a compromise between minimizing the re-excitation error of the emitter and minimizing the number of photons from the leaked field. As a consequence, the optimal pulse strongly depends on the amount of laser leakage from the input field. Importantly, the phase θ of the leaked field matters as there will be interference with the field emitted from the emitter and one cannot simply add the two contributions. Moreover, we show how the leakage fraction is reduced by means of a low-pass filter, which thus strongly reduces $g^{(2)}$. We also study the relation between the second order correlation function and the HOM visibility V. Contrary to the common assumption in the literature of $F = (1-V)/g^{(2)} = 2$, the factor F can attain values anywhere in the interval between $F = [1,3]$ for a good single photon source ($g^2 \ll 1$) depending on the precise nature of the multiphoton component.

References

1. Eva M. González-Ruiz, *et al.*, arXiv:2412.06679 (2024)

Figures

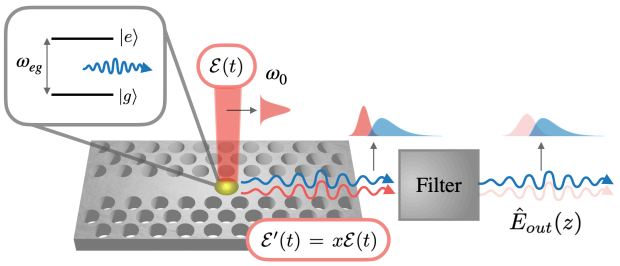

Figure 1: A quantum emitter (yellow semi-sphere) is represented by a two-level system of resonance frequency ω_{eg} with ground state |g> and excited state |e>. The emitter is placed in a waveguide and excited from the top with a coherent field $\mathcal{E}(t)$ of frequency ω_0 that leaks into the waveguide resulting in a field of amplitude $\mathcal{E}'(t) = x\mathcal{E}(t)$, where $x = |x|e^{-i\theta}$ is the leakage factor.

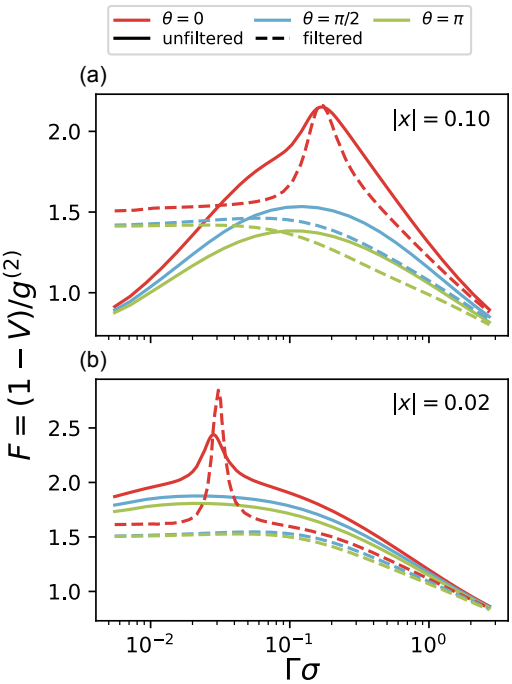

Figure 2: Ratio between lack of visibility and multi-photon emission $F = (1-V)/g^{(2)}$ at different pulse lengths. The filtered values correspond to applying a Lorentzian frequency filter of width $\gamma = 1.7\Gamma$ and the leaked field fraction is set to $|x| = 0.1$ in (a) and $x = 0.02$ in (b). A high value of F indicates that the two-photon component differs from the mode of the single photon component.