Impact of various noise types on the interference of quantum-dot generated photons

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Over the past few decades, there has been increasing research on the development and implementation of quantum communication technologies. This field involves the generation and transport of entangled photons (EPs). Currently, well-established and widely used technologies for information transport via light include optical fiber networks. Additionally, due to their low losses in the telecommunications bands ($\approx$ 1310 nm or 1550 nm), it is optimal for quantum networks to operate within this wavelength range [1]. While photon sources, e.g., quantum dots (QDs) for this range are already available [1] the preparation of single and entangled photons meets unexpected difficulties.

Here, we simulate the Hong-Ou-Mandel (HOM) experiment [2] with two photons from a QD that can be used to assess the indistinguishability of emitted photons. We include several disruptive effects, such as charge and phonon noises in the QD vicinity to check their impact on the experiment outcome. Additionally, we characterize the influence of important imperfections in the experimental setup, including the beam splitter, whose parameters play a critical role in observing the HOM effect. In experimental setups, all the aforementioned effects manifest in the second-order correlation function $g^2(\tau)$, which reflects photon counting statistics at detectors placed along two available photon paths beyond the beam splitter [3]. Thus, we calculate this function for various types of noises and analyze the impact of noise characteristics on the achieved autocorrelation for an otherwise ideal photon source.

Advancing quantum communication technologies necessitates the development of a stable method for generating EPs that can be transmitted via optical networks already in use. To achieve this, it is essential to investigate disruptive phenomena during EP generation. By comparison with experimental data, our results should provide a way to determine the main detrimental factors present in a given system, and further pave the way for their elimination. Finally, understanding how these effects disrupt the EP generation process may contribute to faster development and industrial implementation of quantum information technologies.

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