Coherent generation of Fock-encoded superposition states by realistic QD-based emitters

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The ability of Quantum Dot (QD)-based single-photon sources [1] to generate coherent superpositions of vacuum and single photons of tuneable population p and phase φ when excited coherently [2] has opened exciting perspectives for both quantum communication (twin-field QKD) [3] and quantum computing [4]. A crucial figure of merit for these protocols is the degree of coherence imprinted into the superposition so called Photon Number Coherence (PNC). Single-photon interference visibility in a Mach-Zehnder interferometer, typically used to quantify PNC of superposition states generated by a two-level QD, has yielded visibilities up to 94% with exciton QD-based sources [2]. Recent experimental measurements Fig. 1 have however shown systematically limited visibilities for superposition states emitted by charged exciton (trion). This suggests the need to account for more-than-two-energy-level structures, which is investigated in this study using a time-averaged density matrix model. The model derived not only agrees with the two-level description of [2] but also explains differences in measured visibilities between exciton and trion QD-based sources, originating in the spin dynamics. Moreover, it reveals intrinsic difference between single-photon interference visibility and PNC for more-than-two-energy-levels structures. This model paves the way for the generation of engineered Fock-encoded superposition states with applications in a wide span of quantum information protocols.

References

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Figures

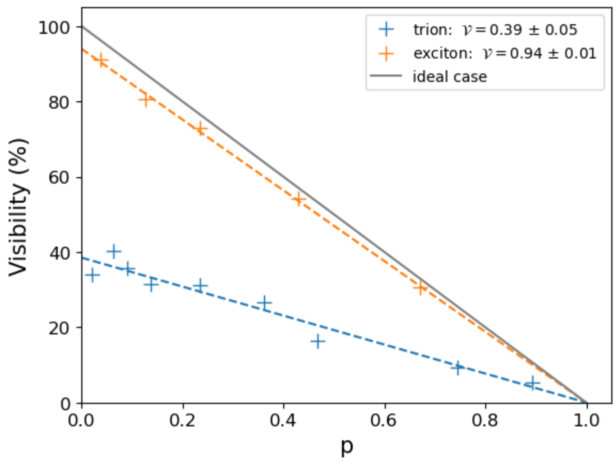

Figure 1: Interference visibility of Fock-encoded superposition states generated by exciton and trion QD-based sources: single-photon interference visibility is asymptotically accessed for small populations p.