Wavevector-resolved photonic entanglement from radiative cascades

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The possibility to generate single and entangled photons have paved the way to the next quantum revolution. Among all different sources, semiconductor quantum dots (QDs) are emerging as one of the main building blocks of the newborn field of quantum networks. Their peculiar electronic structure can be exploited for the generation of polarization entangled photons via two-photon resonant excitation of the biexciton-exciton (XX-X) cascade. While masssive efforts are being devoted to enhance the optical properties of quantum emitters through the integration of optical cavities [**1**], these very latters allowed to put into light fundamental effects that were never experienced before [**2**]. Here [**3**] we exploit $Al_{0.33}Ga_{0.67}As$/GaAs QDs embedded in a cavity based on circular Bragg resonators to investigate the interplay between photon polarization and emission wavevector. We observe how the polarization entanglement of the photon pairs from a XX-X cascade strongly depends on the emission wavevector. In particular, we experiment a drop in quantum correlation as the collection angles get higher due to the increasing polarization degree of the emitted photon pairs. Our experimental results, backed by a theoretical model, yield a new understanding of cascaded emission for a wide variety of quantum emitters. In addition, the model provides quantitative guidelines for designing optical microcavities that retain both a high degree of entanglement and collection efficiency, setting one further step toward an ideal source of entangled photons.

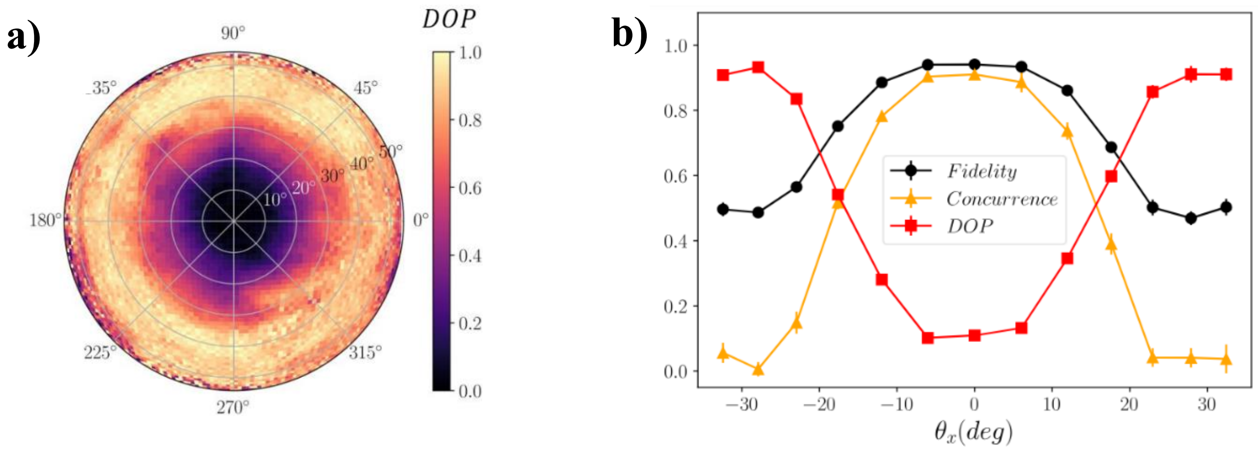

Fig. 1 a) Experimental degree of polarization (DOP) of QDs far-field radiation, sampled throug back focal plane imaging. b) Experimental fidelity of entanglement to the target state $|\phi^+\rangle$, concurrence and average biphoton DOP as a function of the main collection angle, for a fixed small **k** integration range.

[**1**] M. B. Rota, T. M. Krieger, Q. Buchinger, M. Beccaceci, et al., arXiv:2212.12506 (2023)

[**2**] F. Basso Basset, M. B. Rota, M. Beccaceci, et al., Phys. Rev. Lett. **131**, 166901 (2023)

[**3**] A. Laneve, M. B. Rota, F. Basso Basset, M.Beccaceci, et al., in preparation