Polarization-wavevector correlation in entangled photons from cavity-embedded quantum dots

Alessandro Laneve[1]
Michele B. Rota[1]
Mattia Beccaceci[1]
Valerio Villari[1]
Tobias M. Krieger[2]
Thomas Oberleitner[2]
Saimon F. Covre da Silva[2]
Quirin Buchinger[3]
Sandra Stroj[4]
Sven Hoefling[3]
Francesco Bassso Basset[1]
Tobias Huber-Loyola[3]
Armando Rastelli[2]
Rinaldo Trotta[1]

[1]Sapienza University of Rome, Piazzale Aldo Moro 5, Rome, Italy
[2]Institute of Semiconductor and Solid State Physics, Johannes Kepler University, Altenbergerstraße 69, Linz 4040, Austria
[3]Technical Physics, University of Wuerzburg, Am Hubland, D-97074 Wuerzburg, Germany
[4]Forschungszentrum Mikrotechnik, FH Vorarlberg, Hochschulstr. 1, A-6850 Dornbirn, Austria

Alessandro.laneve@uniroma1.it

Reliable generation of entangled photons is crucial for the realization of efficient quantum communication and cryptography protocols. Radiative atomic cascades have been a fundamental resource of quantum light, enabling milestone experiments in quantum information [1, 2]. The development of efficient emitters of the same kind, such as quantum dots, is pivotal for establishing reliable quantum networks [3,4].
An ideal source of this kind is generally regarded as producing maximally entangled photon pairs; on the other hand, seminal works [5,6] highlighted an expected correlation between polarization state of photons and their wavevector, that affects the degree of entanglement.
Such effect is negligible for emitters in vacuum since it occurs to effectively unreachable emission angles. Nevertheless, state-of-the-art emitters are generally embedded in cavity, engineered to enhance the collection efficiency of emitted photons.

We demonstrate that emitters coupled to cavities may feature a pronounced polarization pattern, by experimentally investigating the correlation between polarization and wavevector of photons emitted by GaAs quantum dots embedded in different types of cavities.
We analyse the polarization pattern of the radiation Back Focal Plane, determining the effect on the polarization profile of the cavities. We show that the polarization reshaping is stronger for more efficient cavities, as for the case of bullseyes [7]. By sampling photon pairs using differently sized and differently centred collection cones, we demonstrate a strong interplay between quantum correlation of photons and their wavevectors, a result that can open the path towards the design and the fabrication of near-ideal entangled photon sources in the solid state.

References

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