

# Tailoring photonic correlations with structured light

Carlo Schiano, Bereneice Sephton, Elnaz Darsheshdar, Lorenzo Marrucci, Corrado de Lisio, Vincenzo D'Ambrosio,

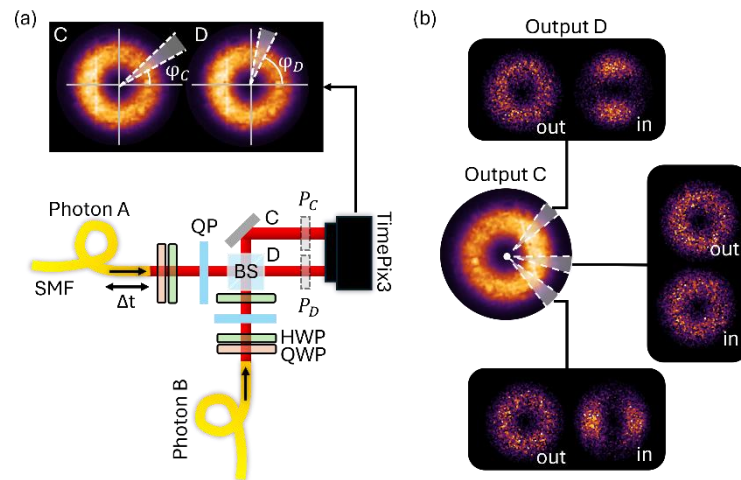
1. University of Naples "Federico II", Department of Physics, Complesso Universitario di Monte S. Angelo, Via Cintia, 80126 Napoli, Italy
2. CNR-ISASI, Institute of Applied Science and Intelligent Systems, Via Campi Flegrei 34, 80078 Pozzuoli (NA), Italy

**Abstract:** We engineer spatial photon correlations by controlling their distinguishability across the transverse degrees of freedom in a quantum interference scheme. The method enables programmable bi-photon correlations, supporting high-dimensional quantum information and imaging.

Photon correlations are a central resource in many quantum optics experiments, with applications ranging from communication protocols to metrology. However, their controlled engineering remains challenging, especially in multi-particle scenarios.

Building on the method introduced in [1], here we introduce a scheme to spatially tailor correlations between photons at two output ports of a beam splitter (BS) [2]. This is achieved by engineering Hong-Ou-Mandel (HOM) interference across the transverse plane through local control of the distinguishability between two input modes with spatially varying polarization. Coincidence measurements are performed with spatially resolving single-photon cameras at the beam splitter outputs, as shown in Fig. 1(a-b). Additional polarization projections after the BS provide further control over the correlation structure.

Our results enable the encoding and transmission of complex, high-dimensional information in photonic correlations, which remain inaccessible to conventional intensity measurements, opening new directions for correlation-based quantum communication and imaging protocols. The proposed scheme naturally extends to multi-particle regimes, providing a scalable platform for quantum technologies.



**Fig. 1** (a) Experimental setup used to generate spatial photon correlations by interfering two structured photons at a 50:50 beam splitter (BS). The top inset shows an example of the selected detection regions used for coincidence measurements in the angular coordinates  $(\varphi_C, \varphi_D)$  of the transverse plane at the two output ports.

(b) Angular dependence of the measured correlations between ports C and D for temporally indistinguishable (in) and distinguishable (out) photons.

SMF: single mode fibre; QWP: quarter-waveplate; HWP: half-waveplate, QP: q-plate; BS: 50:50 beam-splitter;  $P_C, P_D$  : polariser.

## Example References

- [1] C. Schiano, B. Sephton, R. Aiello, F. Graffitti, N. Lal, A. Chiuri, S. Santoro, L. S. Amato, L. Marrucci, C. de Lisio, and V. D'Ambrosio, "Engineering quantum states from a spatially structured quantum eraser.", *Sci. Adv.*10, eadm9278(2024).
- [2] C. Schiano, B. Sephton, E. Darsheshdar, L. Marrucci, C. de Lisio, and V. D'Ambrosio, "Tailoring Spatial Correlations with Quantum Interference.", *Laser & Photonics Reviews* (2026): e02895.