UNIVERSITÀ DEGLI STUDI DI TRIESTE

Dipartimento di Fisica
Dipartimento d'Eccellenza 2023-2027

Trieste Quantum Seminar Series

Tuesday December 9th 2025, at 16:00

Aula A, Edificio F (Dip. di Fisica), via Valerio 2

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Quantum information and sensing with structured light

Abstract: Vectorial modes of light, a type of structured light where the polarization varies across the beam profile, are a useful tool in quantum technologies where they provide large alphabets and rich entanglement structures. In quantum communication, for instance, vectorial modes enable rotational invariant protocols, therefore overcoming the requirement of a shared reference frame between users. Moreover, structured light can be a resource for enhanced sensing purposes as for instance in the "photonic gears" technique. This quantum inspired scheme enables a boost of sensitivity in mechanical displacements measurement thanks to a bidirectional mapping between the polarization state and a properly tailored vectorial mode of a paraxial light beam. By exploiting this technique, we measured, in ordinary ambient conditions, the relative shift between two objects with a resolution of 400 pm [1]. Thanks to a single-optical-path scheme, photonic gears are intrinsically stable and could be implemented as a compact sensor, using cost effective integrated optics.
Finally, structured light can also be exploited for spatial correlation engineering. Photon correlations represent indeed a central resource in quantum optics, with applications ranging from quantum information protocols to sensing. Engineering such correlations is often challenging, especially in multi-particle scenarios. By combining the concepts of structured light and quantum interference we demonstrated a simple and robust scheme to tailor photon correlations directly in the transverse plane. The method relies on locally tuning the distinguishability of photon pairs through spatially structured polarization in a quantum interference setup [2][3]. Our approach could offer an easy extension to multiphoton regimes and provides opportunities for high-dimensional quantum information transfer, with potential applications in quantum communication and imaging.

[1] Nature communications 13.1, 1080 (2022); [2] Science Advances 10.30, eadm9278 (2024);
[3] arXiv:2509.04725 (2025)

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