Engineered resources for multimode Quantum Technologies

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The field of photonic quantum information aims at exploiting quantum states of light to achieve communication and computational tasks that are not classically feasible. In this context, quantum correlation (entanglement) among multiple frequency/time modes is a key resource for quantum technologies, due to the possibility of exploiting an extremely high number of entangled states combined with the possibility of compact and scalable experimental implementation. The field is extremely competitive with important funding worldwide. At the same time, theoretical and experimental applications of multipartite entanglement demand to have access to information-carrying modes that can be individually managed and measured in arbitrary bases. Such condition implies **mastering** the generation of quantum correlations as well as **developing coherent manipulation and measurement techniques** in the desired degrees of freedom.

The scope of this stage work is to investigate theoretically and experimentally the controlled generation and manipulation of highly multimode continuous variable frequency/time entanglement in the continuous variable regime of quantum information encoding. Such a configuration marries the advantage of a high-dimensional quantum alphabet with that of cutting down the physical size of optical systems, both crucial conditions for realistic quantum applications. More in detail, we target the conception and subsequent test in the laboratory of new sources of multimode entanglement, that must be compatible with future integration in photonic circuits for quantum information.

Work plan and objectives:

The proposed work will investigate high-dimension frequency entanglement generated by spontaneous parametric down conversion (SPDC) in pulsed regimes. Multimode features of produced states are determined by acting on the working conditions of the SPDC process, by suitable shaping the SPCD optical pump frequency and temporal profile. The work will be organized around three main tasks:

a) Theoretically simulate the quantum features of light for multimode sources
b) Design and mount a fibered interferometer compatible with pump shaping features
c) Validate the SPDC engineering in classical and, if possible, in quantum photon-counting regime.

This work makes part of a bigger collaboration on multimode states among the Quantum Information and Photonics group of Institut de Physique de Nice and the theoretical group of Multimode Quantum Information of the University of Lille. The candidate will thus have regular exchanges with the partner in Lille. The candidate will work with a PhD student. From the practical point of view, the project will allow the candidate to develop competences in the domains of multimode quantum optics in continuous variable but also in discrete variables encodings, in guided optics, telecom and fibre components, data acquisition and processing, high level electronics.

The endeavors on multipartite quantum optics are essential for the development of operational quantum network and measurement-based quantum computers. The results demonstrated in this project are therefore expected to have major impacts at the international level in quantum information technologies.

A funding for a PhD has been asked on this topic in the context of a project submission. The reply is expected in next months (probably right before the internship start).