UNIVERSITÉ CÔTE D'AZUR

Master thesis proposal

INPHYNI
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Title: Silicon Photonic sources for high-dimension entanglement

Keywords: Multimode entanglement, quantum optics and information

Scientific description: The use of high-dimensional entangled states has recently attracted much attention as they enable the possibility of encoding large amounts of information on correlated photons with a major interest in applied as well as in fundamental quantum optics. On the other hand, integrated photonics on Silicon substrates holds the promise of technological breakthroughs in quantum information technology, due to the possibility of integrating on single photonic chips complex quantum optics experiments, that can be controlled externally and that are compatible with CMOS technologies.

The proposed work sets in the context of the host group ongoing research on quantum correlations in frequency combs out of SiN microresonators operating in different regimes. More specifically, it focuses on entanglement in continuous variable observables of different frequency modes. Quantum correlated modes at emitted each at a different optical frequency but all in the same waveguide; this approach allows scaling up the number of entangled parties without increasing the physical size of the experiments while benefitting of the possibility of easily separating the entangled subsystems thanks to their different colors. Investigating these features for microresonators represents an hot topic in the integrated photonics community at it is primordial to validate their applications to complex quantum technologies tasks as well as to conceive new optimized systems architectures.

The work demanded for this internship focuses on the experimental implementation and verification of entanglement between bright frequency-entangled states, addressing a working regime only poorly investigated so far. The short-term goal of this research is developing experimental toolboxes for the complete characterization of the high-dimensional quantum light from multimode resonators. On the longer term, the demanded works casts the bases to explore applications of the spectral mode entanglement in the quantum comb platform for quantum simulation and quantum communication.

The project benefits of multiple ongoing collaborations. Knowing how to interface with interlocutors and expertise from different scientific backgrounds is one of the skills that will be developed by the candidate during the internship. The theoretical study of entanglement out of microresonators is conducted in collaboration with the university of Lille and the university of Virginia, USA; the candidate will thus be asked to participate to exchanges with these partners in the perspective of contributing to the development of original theoretical tools for entanglement witness. At the same time, exchanges with the partners at LETI CEA that fabricated the microresonators are also to be expected. The practical work allows the candidate to develop competences in both theoretical and experimental multimode quantum optics, thus offering the possibility of achieving a unique and extremely vast panel of skills. The candidate will also develop skills in guided optics, with a special attention to integrated photonics compatible with classical telecommunication and fiber components, as well as in data acquisition and digital processing.

We look for candidates with competences on quantum optics, previous knowledge on continuous variable regime is welcome but not mandatory. Competences on non-linear optics, basic python, electronics and active control systems are equally welcome.

Techniques/methods in use: multimode quantum optics, integrated photonics
Applicant skills: Quantum physics and optics, experimental optics
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