Spécialité de Master « Optique, Matière, Paris »

Proposition de stage (ne pas dépasser 1 page)

Date de la proposition : 25.10.2016

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Code d'identification :UMR7162 — Organisme :Université Paris Diderot/CNRS

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Adresse / *address:* 10 rue A. Domon et A. Duquet 75013 Paris

Lieu du stage / *internship place*: 10 rue A. Domon et A. Duquet 75013 Paris

Titre du stage / *internship title*: ***On-chip generation of quantum states of light***

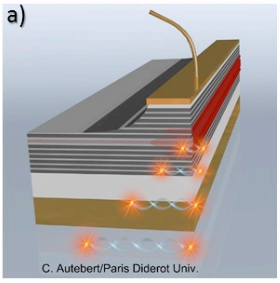
Résumé / *summary* Photonics is playing a key role in the current development of quantum information technologies. The propagation speed of photons and their robustness to decoherence make them an ideal system for quantum communication and cryptography, while photons are also very attractive candidates for metrology and quantum computation. In this context, the current challenge is to attain large-scale applications by miniaturizing and integrating all major components on a single chip. Our team exploits the optical non-linearity as well as the direct bandgap of the III-V semiconductor platform to realize compact sources of twin photons (Fig. a), operating at telecom wavelength and room temperature [1-5].

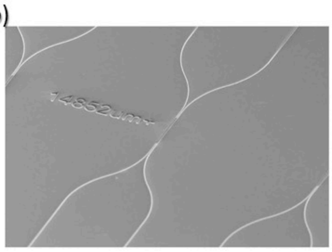
These twin photons can be entangled in various degrees of freedom. In particular, the frequency and the spatial position are two attractive variables for quantum information, as they display a high-dimensional Hilbert space that can be exploited to enhance the density of stored information. In this project we will explore different strategies to generate novel quantum states of light in these two degrees of freedom:

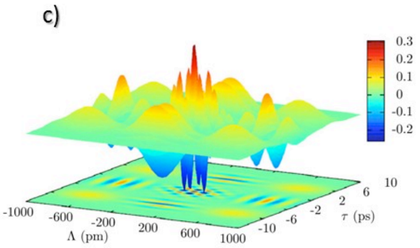
1) We have shown that in a waveguide, the entanglement in frequency can be controlled through the spatial profile of the pump beam [1,3]. During the internship/thesis we will use a Spatial Light Modulator (SLM) to precisely tailor the spatial phase and intensity of the pump beam. This will allow to generate *Schrödinger cats* of light, and even more complex states such as *compass states* (Fig. c), a superposition of four coherent states presenting promising applications in quantum metrology.

2) We will couple several semiconductor waveguides to create a one-dimensional lattice of waveguides. In this configuration, the photons can randomly jump from one waveguide to the other (*quantum walks*) and interfere to produce spatially entangled states of light. This device will allow us to explore an important aspect of quantum computation, the *boson sampling*, a problem thought to be exponentially hard to solve by a classical computer but accessible to a quantum computer [6].

3) We will work on the integration of the two above sources in a complete photonic circuit, in line with our recent demonstration of the electrical injection of the pump beam [2] and our current work on integrated beam splitters (Fig. b) to realize on-chip quantum optics experiments.







The candidate will have the possibility to participate to all aspects of the project, from the clean-room fabrication of the devices to the quantum optics experiments and the theoretical analysis, in synergy with the theoreticians of our *Quantum Information Technologies* team. The work will benefit from our numerous collaborators in France and abroad.

[1] A. Orieux et al., **Phys. Rev. Lett**. 110, 160502 (2013).
[2] F. Boitier et al., **Phys. Rev. Lett**. 112, 183901 (2014).
[3] G. Boucher et al., **Phys. Rev. A** 92, 023804 (2015).
[4] C. Autebert et al., **Optica** 3, 143 (2016).
[5] C. Autebert et al., **arXiv**:1607.01693 (2016).
[6] A. Broome et al., **Science** 339, 794 (2013).

Ce stage pourra-t-il se prolonger en thèse ? *Possibility of a PhD* **? : oui**

Si oui, financement de thèse envisagé/ *financial support for the PhD***:** DGA, DSTL, Doctoral School, ...

Lumière, Matière, Interactions	X	Lasers, Optique, Matière	X