Spécialité de Master « Optique, Matière, Paris »

Stage de recherche (4 mois minimum, à partir de début mars)

Proposition de stage

Date de la proposition : 7 novembre 2016

Responsable du stage / *internship supervisor*: Julien Laurat

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Nom du Laboratoire / *laboratory name*:

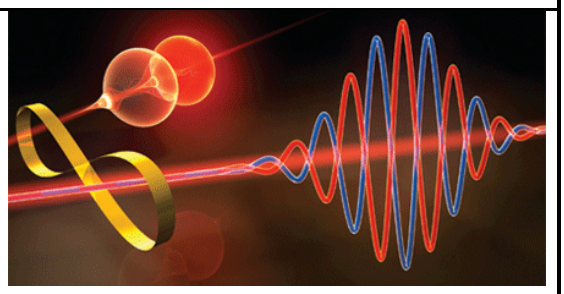
Code d'identification : UMR 8552 — Organisme : Laboratoire Kastler Brossel

Site Internet / *web site*: quantumoptics.fr

Adresse / *address:* 4 place Jussieu, Paris 05

Lieu du stage / *internship place*: UPMC

Optical Hybrid Quantum Information



In analogy to what has happened for classical signals with the **digital and analog paradigms**, quantum information has developed along **two traditionally separated lines**, known as the **discrete- and the continuous-variable approaches**.

In the optical approach, the **wave-particle duality of light** has naturally led to this distinction. The discrete-variable approach involves for instance **single photons** and the states live in a finite-dimensional space spanned, among others, by orthogonal polarizations or the presence and absence of single photons. In the continuous-variable alternative, the encoding is realized in the **amplitude or phase of a light field**, in an inherently infinite-dimensional space. The typical detection and processing tools are different, based either on photon counting or homodyne detection. A variety of groundbreaking experiments have been realized using one or the other paradigm.

However, in recent years, few groups, including the LKB team, have tackled the effort to **combine the two approaches**, integrating continuous- and discrete-variable tools and concepts in **optical hybrid realizations**. These protocols can overcome some limitations of the schemes taken individually or provide novel capabilities. An illustrative protocol realized at LKB consisted in witnessing single-photon entanglement up to 100 km using only homodyne measurements, an example of realization where the combination of the toolboxes can be an enabling pathway. Recently the team also demonstrated for the first time a so-called **hybrid entanglement of light** between particle-like and wave-like qubits to bridge the two approaches.

The team aims now at exploring the **uniqueness and benefits of hybrid entanglement light and at harnessing this yet unexplored photonic resource to realize first advanced protocols**. This resource opens up the promise of heterogeneous quantum protocols and networks where the two encodings can be combined or interconverted in the form best suited for a particular process. The experimental effort will include for instance the realization of an analog-to-digital converter for quantum information via teleportation. Hybrid entanglement of light can be also be seen by itself as a novel type of qubit with a double encoding and first principles of quantum computing with this resource will be explored.

These researches involve non-linear optics, quantum state generation and characterization, superconducting single-photon detectors (in collaboration with NASA and NIST)…

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

Si oui, financement de thèse envisagé/ *Doctoral school or others*

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