Master 2: *International Centre for Fundamental Physics*

INTERNSHIP PROPOSAL

Laboratory name: Matériaux et Phénomènes Quantiques
CNRS identification code: UMR7162
Internship director'surname: DUCCI Sara
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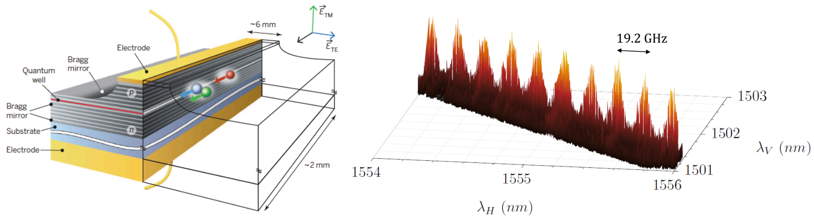
Internship location: Campus Paris Rive Gauche Bâtiment Condorcet
Thesis possibility after internship: YES
Funding: several possibilities to explore (DGA, Doctoral School, DIM SIRTEQ, ..)

Semiconductor sources of quantum states of light at room temperature: from fundamental studies to applications in quantum information protocols

Scientific project: The generation of nonclassical states of light in miniature chips is a crucial step toward practical implementations of future quantum technologies. For the sake of practicality and scalability, these quantum sources should be easily produced, operate at room temperature, and be electrically excited and controlled. The work of the QITe team is focused on AlGaAs-based quantum photonic devices: indeed, this platform presents a strong case for the miniaturization of different quantum components in the same chip: strong second order nonlinearity and electro-optic effect, direct bandgap, generation of entangled photons in the telecom band. After the demonstration of the first electrically driven device working at room temperature [1] and the generation and symmetry control of biphoton frequency combs [2], in this project the QITe team will push further the capabilities of its devices:



Left: sketch of an electrically driven photon pair source working @ room T; Right: measurement by stimulated emission tomography of the biphoton frequency comb emitted by our devices

- we will study the entanglement properties of the state emitted by electrically injected devices
- we will add novel on-chip functionalities to manipulate the photons polarization (polarizing beam splitter), their relative delay (electro-optics effect) and manage the facets reflectivity to avoid or enhance cavity effects.
- we will exploit the assets of the states emitted by our devices (wide spectral band, frequency anti-correlation and polarization entanglement) for the implementation of entanglement-based multi-user quantum key distribution either connecting several pairs of users [3], implementing quantum networks or new protocols for quantum metrology.
- we will explore the comb structure of the emitted state to investigate its possible application in quantum information protocols and to demonstrate that high-dimensional QKD can be used in practice to increase the density and security of communication.

This project will combine device design and fabrication, quantum optics measurements/theory and applications to QI protocols. It will benefit from the collaborations of the team with the Center of Nanosciences and Nanotechnologies, the team of E. Diamanti at LIP6 and Nokia-Bell Labs.

[1] F. Boitier et al. Phys. Rev. Lett. 112, 183901 (2014)
[2] G. Maltese et al. npj Quantum information 6, 13 (2020)
[3] C. Autebert et al. Quantum Sci. Technol. 1 01LT02 (2016)

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: YES Macroscopic Physics and complexity: NO
Quantum Physics: YES Theoretical Physics: NO