Spécialité de Master « Optique, Matière, Paris »

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

Proposition de stage (ne pas dépasser 1 page)

Date de la proposition :

Responsable du stage / *internship supervisor*:

Nom / *name*: SENELLART   Prénom/ *first name* : Pascale

Tél : 01 70 27 05 67   Fax :

Courriel / *mail*: pascale.senellart-mardon@c2n.upsaclay.fr

Nom du Laboratoire / *laboratory name*:

Code d'identification : UMR9001   Organisme :CNRS – Université Paris Saclay

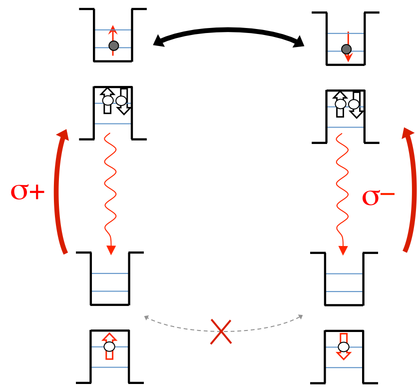
Site Internet / *web site*: c2n.universite-paris-saclay.fr

Adresse / *address:* Avenue de La Vauve, 91120 Palaiseau

Lieu du stage / *internship place*: Avenue de La Vauve, 91120 Palaiseau

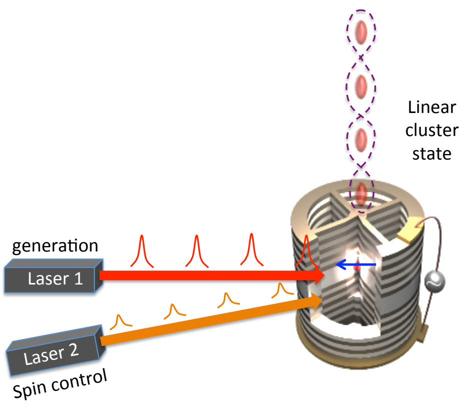
Generation of large entangled photon states with semiconductor quantum dots

Quantum light is at the heart of many quantum technologies, such a optical quantum computing or quantum communications. Single photons are excellent quantum bits as they show no interaction with the environment, hence no decoherence, and allow to propagate the quantum information over long distances. One of the key resources is states of light where several photons are entangled in one of their degrees of freedom. A special class of such states, the cluster states, are essential to scale up quantum computing.



The project of this internship/PhD work is to investigate the generation of photon cluster states using a single semiconductor quantum dot. Quantum dots are artificial atoms that have been shown to generate indistinguishable single photons at the highest rate to date [1,2]. Here, we will exploit an additional degree of freedom, the spin state of a single carrier in the quantum dot, to generate chains of entangled photons.

The idea, theoretically proposed in ref [3], is to make use of spin-photon entanglement that results from the optical selection rules. We consider for instance a trion transition in a quantum dot, connecting a hole to a trion state consisting of two holes and an electron. Right (left) handed circular light couples only to up (down) spin ground states, so that if the spin is up, it is only excited and only emits right handed circular polarized light. Starting from a spin superposition $|\Uparrow\rangle + |\Downarrow\rangle$ and exciting with linearly polarized light leads to the generation of an entangled spin-photon state.



To entangle several photons, the same optical transition will be excited several times during the coherence time of the spin and each produced photon will be entangled with the same spin. A N-photon entangled state will be obtained upon strong measurement of the spin at the end of the process.

Our team has long experience of single photon generation with single quantum dots. Over the years, we have developed a technology that allows generating single photons at the highest rate, with an electrical control of a single quantum dot transition. The objective of the internship will be to develop optical tools to control the state of the spin in these devices. The work will be followed by a PhD project dedicated to the generation of two photon-entangled state at very high rate, progressively moving toward higher photon numbers.

All experimental expertise exists in the group, both on the technological and experimental side to sucessfully lead this project. Moreover, we have many collaborations with theory groups as well as specialists of optical quantum computing. We welcome excellent students with solid training in quantum physics and/or optics, with a real taste for experimental studies and team work.

[1] Somaschi, Giesz, De Santis, Loredo, P Almeida, Hornecker, Luca Portalupi, Grange, Antón, Demory, Gómez, Sagnes, Lanzillotti-Kimura, Lemaítre, Auffèves, White, Lanco, and Senellart, ***Near-optimal single-photon sources in the solid state.*** **Nature Photonics 10**, 340–345 (2016).
[2] P. Senellart, G. Solomon, A. White, ***High-performance semiconductor quantum-dot single-photon sources***, **Nature Nanotechnology 12**, 1026 (2017)
[3] Lindner, N. H. & Rudolph, T. ***Proposal for Pulsed On-Demand Sources of Photonic Cluster State Strings***. **Phys. Rev. Lett. 103**, 113602 (2009)

Methods and techniques: The proposed work is mostly experimental, performing quantum optics on single nano-objects. We use all the tools of optical confocal microscopy as well as photon correlations techniques to characterize and control the single photon and the quantum **dot states.**

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***:Bourse DGA**

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

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