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

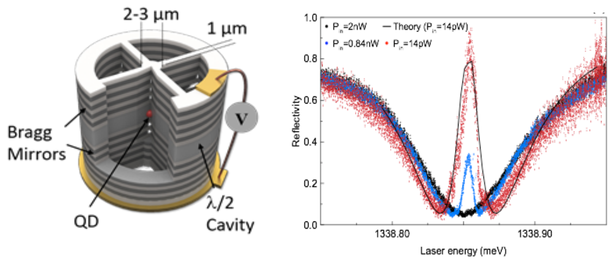
Adresse / *address:* Avenue de La Vauve, 91120 Palaiseau

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

Investigation of energy exchanges at the quantum level

Quantum thermodynamics is an emerging field that aims at solving problems of both fundamental and practical nature, addressing simple questions such as how to define heat, work and entropy production in the quantum regime? Is quantum coherence some energetic resource? What is the energetic cost of quantum information processing? Such open questions are essential to address, especially now that quantum technologies are rapidly progressing.

The objective of this internship/PhD work is to experimentally investigate evidences of quantum thermodynamic signatures related to the presence of coherence in a model quantum device. The project proposes to implement a quantum "engine" based on a single artificial atom (a semiconductor quantum dot) in a cavity coupled to a laser field. By placing a single atom in a cavity, one can control its coupling to light at will. Symetrically, the optical response of an incoming light field allows to measure the atomic qubit state very efficiently. This unique experimental configuration allows to detect energy exchanges between the light field and the atom at the sing le quantum level.



Left: Schematic of the device under study: a quantum dot is placed at the center of an optical microcavity. Right: Reflectivity measured on a device as a function of excitation power. At low power (red points, black curve), the reflectivity shows a very high reflectivity peak due to the coherent response of the atom. Power dependence shows that a single photon is sufficient to saturate the atomic transition [3].

In this project, we will first demonstrate that we can control the energy dissipation of quantum bit. We will cool down the system in a state that presents optimal work exchange with the reservoir light field. We will then study the influence of the coherence on the work extraction. All experimental techniques are in place to conduct this project. Our team as long expertise in coupling single quantum dot to microcavities in a fully controlled way [1]. Doing so, we recently demonstrated the possibility to control the atom (quantum dot) state [2] and to measure the non-linear atomic response at single photon scale [3]. Our studies show that semiconductor quantum dot systems acts as the textbook model of cavity quantum electrodynamics, where decoherence can be made negligible [4].

This PhD work takes place within the ANR project Qu-Dice, where our team collaborates with the group of Alexia Auffeves (Institut Néel Grenoble) and Igor Dotesenko (Collège de France) to study quantum thermodynamics in cavity quantum electrodynamics systems. We welcome excellent students with solid training in quantum physics and 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] V Giesz, N Somaschi, G Hornecker, T Grange, B Reznychenko, L De Santis, J Demory, C Gomez, I Sagnes, A Lemaître, O Krebs, ND Lanzillotti-Kimura, L Lanco, A Auffeves, P Senellart, ***Coherent manipulation of a solid-state artificial atom with few photons.*** **Nature Communications 7**, 11986 (2016).

[3] De Santis, Antón, Reznychenko, Somaschi, Coppola, Senellart, Gómez, Lemaître, Sagnes, White, Lanco, Auffèves

and Senellart, ***A solid-state single-photon filter***, **Nature Nanotechnology 12**, 663 (2017).
[4] JC Loredo, C Antón, B Reznychenko, P Hilaire, A Harouri, C Millet, H Ollivier, N Somaschi, L De Santis, A Lemaître, I Sagnes, L Lanco, A Aufféves, O Krebs, P Senellart, ***Generation of non-classical light in a photon-number superposition***, **arXiv**:1810.05170

Methods and techniques: The proposed work is mostly experimental, performing quantum optics on single nano-objects, using tools of optical confocal microscopy as well as photon correlations techniques. This project, in an emerging field of physics will also be conducted in close collaboration with theorists to guide the experiments efficiently.

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*: **PhD Funded by ANR Qu-DICE 2019-2022**

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

Fiche à transmettre (fichier pdf ***obligatoirement****) sur le site http://stages.master-omp.fr*