Spécialité de Master « Optique, Matière, Plasmas »

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

Proposition de stage (ne pas dépasser 1 page)

Date de la proposition : 05/11/2014

Responsable du stage / *internship supervisor*:

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Nom du Laboratoire / *laboratory name*: Laboratoire Aimé Cotton

Code dôidentification: UPR3321 — Organisme :CNRS

Site Internet / *web site*: http://www.lac.u-psud.fr/spip.php?rubrique199

Adresse / *address:*

Lieu du stage / *internship place*: Laboratoire Aimé Cotton

Titre du stage / *internship title*: **Carbon nanotubes single photon sources**

Quantum communications bring together different emerging technologies using the laws of quantum mechanics in order to exchange inviolable encrypted keys. Several proofs of concept have been shown using single photons emitters such as molecules[1,2], NV centres in diamond[3,4], semiconductors nanocrystals[5, 6] or self assembled quantum dots[7]. For instance, entanglement at room temperature between two NV centres has been reported recently[8]. One can also mentioned the quantum teleportation of a single photon emitted by a single self assembled quantum dot[9,10]. Nevertheless, all these very nice experiments have been performed at wavelengths ranging from the visible to near infrared (~900nm). The deployment of quantum information technology outside the laboratory, such as long distance quantum cryptography, requires the development of quantum emitters working at telecommunication wavelengths (1.3µm or 1.5 µm). In order to reach these wavelengths, one possibility is to use parametric conversion. Nevertheless, these complicated processes may encounter large losses (up to 50%). Another possibility is to use attenuated laser or parametric sources. However, these sources do not provide single photon states and the probability of producing two (or more)-photon states limit the fidelity of the communication. Therefore, the most efficient way to obtain such quantum light sources would be to use single emitters which emit single photons at telecommunications wavelengths. First, self assembled InAs/InP quantum dots emit single photons in this spectral range. Nevertheless, their growth is not as controlled as the one of InAs/GaAs quantum dots (emission at ~900nm). Moreover, quantum states delivered by these sources are not pure enough in terms of unicity of the emitted photons, indistinguishability and entanglement.

During this internship, and the thesis that follows, we will explore one alternative: single wall carbon nanotubes. Indeed, it has been shown recently that carbon nanotubes could be single photon sources[11,12,13]. This observation opens a whole field of research in quantum optics of this 1D object. This internship will address the question of the origin of the antibunching behaviour of the nanotube emission. The applicant will study the statistics of light emission of carbon nanotubes using a microphotoluminescence experiment coupled with a Handbury-Brown and Twiss setup in the near infrared. Cryogenic techniques will be used to study the influence of temperature on these statistics (from 10 K to 300K). These experiments can be compared to ultrafast optical experiments also conducted in the lab. Finally, the applicant will use and develop theoretical models related to the above experiments. The applicant should have a good knowledge of solid state physics and optics.

[1] T. Basché *et al.* Phys. Rev. Lett. **69,** 1516 (1992); [2] B. Lounis *et al.* Nature **407,** 491 (2000) ; [3] C. Kurtsiefer *et al.* Phys. Rev. Lett. **85,** 290 (2000); [4] A. Gruber *et al.* Science **276,** 2012 (1997) ; [5] B. Lounis *et al.* Chem. Phys. Lett**. 329,** 399 (2000) ; [6] P. Michler *et al.* Nature **406,** 968 (2000) ; [7] P. Michler *et al.* Science **290,** 2282 (2000) ; [8] F. Dolde *et al.* Nature Physics **9,** 139 (2013) ; [9] W. B. Gao *et al.* Nature Communication **4,** 2744 (2013) ; [10] J. Nilsson *et al.* Nature Photonics **7,** 311 (2013) ; [11] A. Högele et al. Phys. Rev. Lett. 100, 217401 (2008); [12] W. Walden-Newman *et al.* Nano Lett. **12,** 1934 (2012) ; [13] M. S. Hofmann *et al.* Nature Technology **8,** 502 (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***: Privé, Ecole Doctorale**

Lasers, Optique, Matière	**OUI**	Lumière, Matière, Interactions	**OUI**
Plasmas : de lôespace au laboratoire	**NON**		

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