Spécialité de Master « Optique, Matière, Plasmas »

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

Proposition de stage

Date de la proposition : 22/11/2016

Responsable du stage /*internship supervisor*

Nom/*name* : Palpant — Prénom/*first name* : Bruno

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Nom du Laboratoire / *Laboratory name* : Laboratoire de Photonique Quantique et Moléculaire

Code d'identification : UMR 8537 — Organisme : CNRS-ENS Cachan-CS

Site Internet/*web site* : http://www.lpqm.ens-cachan.fr/

Adresse/ *address* : ENS Cachan, 61 av. du Président Wilson, 94235 Cachan cedex

Lieu du stage/ *Internship place*: CentraleSupélec, Châtenay-Malabry et ENS Paris-Saclay, Cachan

Titre du stage / *internship title*: **From localized plasmon to nanoscale plasma: gold nanoparticles for photodynamic therapy**

- **Context.** The interaction of metal nanoparticles and ultrashort laser pulses results in a series of transient phenomena which can be exploited for biomedical means. We have recently demonstrated the ejection of electrons from isolated gold nanorods under infrared pulsed laser irradiation tuned to their longitudinal localized plasmon mode. This induces the generation of a nanoscale plasma and further reactive oxygen species (ROS) over a large spatial range[1]. The latter are known as sources of oxidizing stress for cells, which is the basic mechanism of photodynamic therapy against cancer[2,3]. In addition, the nanoparticles exhibit an ultrafast photo-luminescence covering the whole visible spectral domain. All these processes are of multiphotonic origin through the production of a hot electron gas within the nano-objects. However, several challenges are still to be tackled to understand the basic mechanisms and optimize the biomedical application.

- **Objectives and issues.** The main goal of the internship is to identify the nature of the different ROS produced as well as their spatial localization. The efficiency of different nanostructures will be compared, in order to reveal the role played by the plasmonic modes. Optionally, we will determine the dynamics of the generation of solvated electrons from the nanoparticles.

- **Work to achieve.** The student will elaborate hydrogel films containing gold nanostructures with different shapes. He/she will perform and analyze the fluorescence microscopy imaging of individual nanoparticles irradiated by femtosecond laser pulses, and possibly ultrafast transient absorption spectroscopy experiments[4] to reveal the dynamics of solvated electrons.

- **Outlooks.** This internship is likely to be followed by a PhD thesis. Models will be developed to catch the physics of the series of phenomena involved. The multiphoton-induced ultrafast luminescence will be studied on individual nano-objects and the role of the plasmon modes will be analyzed. In parallel, the electron ejection dynamics will be measured by photoelectron emission microscopy (in collaboration). Beyond, the seek for an efficient ROS generation from direct ionization of water molecules will be carried out, as this is still a very challenging issue in treatments of resistant hypoxic cancer tumors. A partnership with a biomedical laboratory in St-Louis hospital (Paris) will allow us to determine *in vivo* the efficiency of our irradiated nanoparticles and to optimize a protocol for further therapies.

1. T. Labouret *et al., Small* **11**, 4475 (2015).
2. L. Gao *et al*., *ACS Nano* **8** (7), 7260–7271 (2014).
3. L. Minai *et al*., *Nano Lett.* **16** (7), 4601–4607 (2016).
4. X. Wang *et al.*, *J. Phys. Chem. C* **119**, 7416 (2015).

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***: Allocation de thèse ED ou autre (demande en cours)**

Lumière, Matière, Interactions	**oui**	Lasers, Optique, Matière	**oui**