Spécialité de Master « Optique, Matière, Paris »

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

Proposition de stage

Date de la proposition : 25/10/2017

Responsable du stage / *internship supervisor*:	
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Nom du Laboratoire / *Laboratory name* : Laboratoire de Photonique Quantique et Moléculaire	
Code d'identification : UMR 8537	Organisme : CNRS-ENS Paris-Saclay-CS
Site Internet/*web site* : http://www.lpqm.ens-cachan.fr/	
Adresse/ *address* : ENS Paris-Saclay, 61 av. du Président Wilson, 94235 Cachan cedex	
Lieu du stage/ *Internship place*: CentraleSupélec, 3 rue Joliot Curie, 91190 Gif-sur-Yvette	

Titre du stage / *internship title*:

Ultrafast multiphotonic processes in plasmonic nanoparticles

- **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, later, optimize the biomedical application. The team leads a multidisciplinary project, grouping 5 partners, which has recently be awarded a funding by the "Plan Cancer" of INSERM.

- **Objectives and issues.** The main goal of the internship is to determine the dynamics of the generation of solvated electrons from the nanoparticles. The efficiency of different nanostructures will be compared, in order to reveal the role played by the plasmonic modes.

- **Work to achieve.** The student, depending on his/her wishes, will either perform ultrafast transient absorption spectroscopy experiments[4] to reveal the dynamics of solvated electrons, or model and simulate numerically the dynamics of multiphotonic ejection of electrons as well as its dependence on the plasmonic near field topography.

- **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**