Master 2: *International Centre for Fundamental Physics*

INTERNSHIP PROPOSAL

Laboratory name: **Institut des Sciences Moléculaires d'Orsay** *(ISMO – Univ. Paris-Saclay)*
Laboratoire Charles Fabry *(LCF – Institut d'Optique)*

CNRS identification code: ISMO UMR 8214 – LCF UMR 8501

Internship director'surname: Elizabeth Boer-Duchemin (ISMO) / Jean-Jacques Greffet (LCF)

e-mail : elizabeth.boer-duchemin@universite-paris-saclay.fr

Phone number: 01 69 15 73 52

Web page: http://www.ismo.universite-paris-saclay.fr/spip.php?rubrique199

Internship location: ISMO, Bât. 520, Université Paris-Saclay

Thesis possibility after internship: **YES**

Funding already obtained for a PhD : **YES, ANR funding (dir : E. Boer-Duchemin/JJ Greffet)**

Towards an efficient miniaturized light source based on quantum tunneling

In order to reduce the power consumption of today's ever-densified circuits, optical connections for on-chip or chip-to-chip communication are considered a promising solution. The best available sources, however, cannot be modulated faster than 1 GHz due to the spontaneous emission rate of the excited carriers.

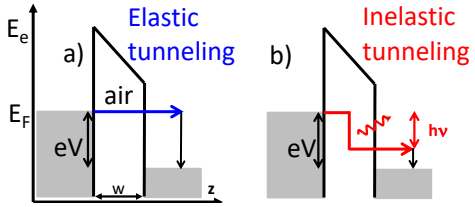


Figure 1: Light emission by inelastic tunneling: an insulating layer of width w separates two metals. Applying a voltage V generates an electric tunnel current (a) and an inelastic current (b) which generates photons.

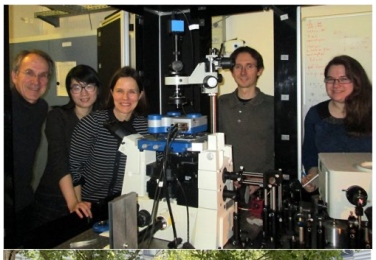
The goal of this internship is to work **toward a light emitting source based on the inelastic quantum tunneling effect.** As shown in the figure, most often electrons cross a biased tunnel junction elastically, i.e., without losing their energy. A small percentage, however, undergo inelastic tunneling, losing all or a part of their excess energy in the barrier, leading to the emission of photons. The idea of this project is **to design, produce and test a structure in which elastic tunneling is completely suppressed, thus leading to the efficient excitation of photons**. In particular, in this internship, the goal will be to assess the quality of the fabricated structures at the nanoscale using conducting atomic force microscopy (C-AFM). The metallized AFM tip will also be used as an antenna to open up radiative channels and measure the local optical properties.

During this internship, the student will acquire experience in **(i) atomic force microscopy** (imaging and conductivity measurements) **(ii) antenna theory and quantum tunneling** and **(iii) optical microscopy (the detection and analysis of the emitted light)**.

A PhD can follow the internship with co-supervision from the Nanophys team at ISMO and the Quantum Nanophotonics and Plasmonics team at IOGS.

The Nanophys team at ISMO studies the optical, electrical, structural and dynamical properties of atomes, molecules and nano-objects using photons, electrons, atoms and numerical methods.

The Quantum Nanophotonics and Plasmonics team at the Institut d'Optique investigates the physics and engineering of spontaneous light emission (fluorescence, incandescence, electroluminescence, at different scales (quantum regime with single photon and single atoms, condensates, collective effects, photon condensates, condensed matter).



References to related works from the teams :

[Zhang 2019] *Zhang C. , J.P. Hugonin, A.L. Coutrot, C. Sauvan, F. Marquier, J.J. Greffet,* Antenna surface plasmon emission by inelastic tunneling, *Nature Communications* ***10****, 4949 (2019). doi.org/10.1038/s41467-019-12866-3*

[Wang 2011] *Wang, T., Boer-Duchemin, E., Zhang, Y., Comtet, G. & Dujardin, G.* Excitation of propagating surface plasmons with a scanning tunnelling microscope, *Nanotechnology* **22**, 175201 (2011).

Condensed Matter Physics:	**YES**	Soft Matter and Biological Physics:	**NO**
Quantum Physics:	**YES**	Theoretical Physics:	**YES**