# Master 2: *International Centre for Fundamental Physics*

## ***INTERNSHIP PROPOSAL***

Laboratory name: Laboratoire de Physique des Solides
CNRS identification code: UMR 8502
Internship director'surname: Alexandra Palacio Morales (Marco Aprili)
e-mail: alexandra.palacio-morales@u-psud.fr Phone number: +33 16915 8011
Web page: https://www.equipes.lps.u-psud.fr/ns2/index.shtml

Internship location: Laboratoire de Physique des Solides (LPS) ; 1 rue Nicolas Appert, Bât. 510, 91405 Orsay

Thesis possibility after internship: YES
Funding: YES/NO If YES, which type of funding:

**Atomic scale shot-noise of a superconductor**

Many interesting properties in condensed matter systems originate from interactions between electrons. Since these interactions usually take place on short timescales, a measurement of time-averaged properties is often missing crucial information. In order to gain *access to interactions and electron dynamics* the NanoStructures @ NanoSecond team (N2S) has recently developed a *scanning tunneling microscope* that can measure current fluctuations with atomic scale spatial precision [1, 2]. In this project you will use this system to investigate electron correlations and dynamics in superconductors.

One of the questions we are interested in is *what happens when* a *defect or impurity is introduced to a superconductor*, especially when the impurity is magnetic, meaning it has a nonzero spin. Two processes can occur in this case: (1) the spin is screened by electrons with opposite spin that hop on and off the site, a quantum mechanical process called Kondo screening, or (2) the spin is not (or insufficiently) screened and acts as a pair-breaking potential leading to one or more states inside the superconducting excitation gap. The latter case is particularly interesting as the single spin is protected from scattering or decoherence by the superconducting excitation gap, in principle allowing one to drive the spin and study spin dynamics at the atomic scale. These states are the precursors for Majorana Physics [3, 4].

In this project you will first become familiar with the scanning tunneling microscopy (STM) setup, characterize the atomically sharp tip and calibrate the finite frequency circuitry through shot-noise measurements on standard metals such as platinum. The next step is to investigate a superconductor doped with magnetic impurities, find the impurities and discover what happens at and around them at the atomic scale, using both conventional STM techniques, as well as shot-noise at finite frequency.

[1] Review of Scientific Instruments ***89***, *093708 (2018)*
[2] Nature Communications ***10***, *544 (2019)*
[3] Science Advances ***4***, *eaar5251 (2018)*
[4] Science Advances ***5***, *eaav6600 (2019)*

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

| | | | |
|---|---|---|---|
| Condensed Matter Physics: | YES | Soft Matter and Biological Physics: | NO |
| Quantum Physics: | YES | Theoretical Physics: | NO |