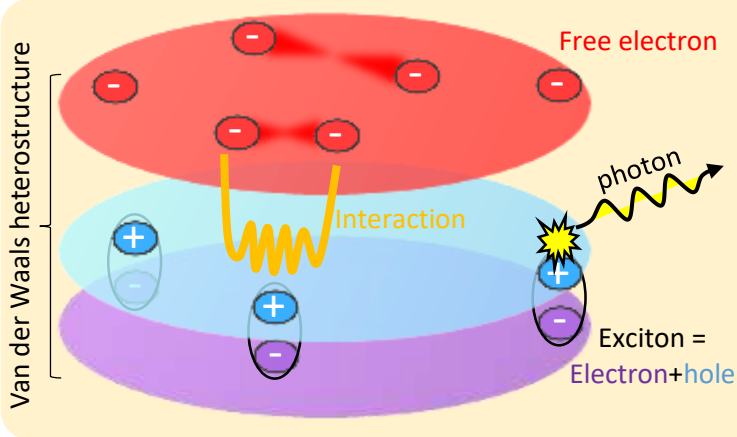
INTERNSHIP PROPOSAL

Laboratory name: Institut des NanoSciences de Paris (INSP)
CNRS identification code:
Internship director': Bertrand Evrard
e-mail: Bertrand.evrard@cnrs.fr
Internship location: Campus Pierre et Marie Curie
Thesis possibility after internship: YES
Funding: NO

Bosons and fermions in van der Waals heterostructures

The project focuses on mixtures of electrons (fermion) and excitons (electron-hole pair, a boson) in a new class of materials: van der Waals heterostructures. The latter can be seen as a "mille-feuille", obtained by stacking atomically thin sheets of various materials. They recently became a prominent platform to study many-body physics, after a milestone discovery of superconductivity in bilayer graphene. Our long term ambition is to introduce superconductivity in a controlled manner, using excitons as force-carrier bosons (instead of phonons in conventional superconductors). The internship will pave the way toward this goal. It includes two steps, (i) the fabrication of the heterostructures and (ii) a first characterization with optical spectroscopy.



We mix electrons and excitons in a trilayer structure. Excitons are short-lived, and recombine by emitting a photon. By collecting the luminescence light, we can investigate the nature of the exciton-electron interactions.
In the long term, excitons will be used as a force carrier between free electrons to enable their pairing and, in turn, superconductivity.

The intern will learn the basics of the fabrication of van der Waals heterostructures [3]. They will participate in implementing a new method, to improve the quality of the devices and increase the fabrication yield. The core of the device includes three layers of so-called transition metal dichalcogenides (TMDs), which can be seen as semiconducting cousins of graphene. One such semiconductor will be electrostatically doped with free electrons. The other two will host electrons and holes (an electron vacancy) forming a bound state, akin to a hydrogen atom: an "exciton". The electron and hole can annihilate by emitting a photon, as a particle and antiparticle would. The purpose of using a bilayer is to separate the two particles on different layers to inhibit the recombination. Yet, recombination is never fully suppressed, which turns out to be an asset. Indeed, by probing the luminescence spectrum, the intern will investigate the electron-exciton interaction.
The applicant should be a highly motivated and curious student, with a strong taste for experimental physics. A background in condensed matter physics and/or optics is appreciated, but not necessary.

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