MASTER ICFP

Internship offer

Laboratory: LPENS (Lab. Physique de l'ENS)
Director: JM Berroir
Address: ENS, 24 rue Lhomond, 75005 Paris
Person in charge of the internship: Christophe Voisin
e-mail: christophe.voisin@phys.ens.fr / Tel: 0144323845

Mixed dimensions van der Waals hetero-structures as a plateform for quantum photonics

In recent years the assets of carbon nanoemitters (carbon nanotubes, graphene quantum dots, graphene nanoribbons...) as a new plateform for quantum photonics (quantum communications and quantum information processing) have driven a lot of efforts, including in our group. In fact, their optical properties show a remarkable versatility due to the full control over the working wavelength using quantum confinement in gapless graphene.
Several successful approaches have been developed using either chemical grafting of color centers in carbon nanotubes or chemically synthetized graphene dots or ribbons to tune their optical properties and make their features of single quantum emitters more robust. Room temperature single photon emission has been demonstrated in all of these systems showing the effectiveness of the approach.

However, in most cases the intrinsic photophysics of these nano-emitters is blurred by spurious effects related to the interaction with environment (dephasing processes, spectral diffusion, polarization selectivity...). A promising approach is based on the encapsulation of individual nano-emitters in a layered structure of wide-gap 2D materials, known as a mixed-dimension van der Waals heterostructure. In fact, this approach brings a atomically clean environment for the nano-emitter that can be created on a table top setup, without the burden of ultra-vacuum environment as for the fabrication of regular (III-V) hetero-structures. In addition, conductive 2D materials such as graphene bring the possibility to gate the emitter thereby reducing electrostatic fluctuations responsible for spectral diffusion.

We developed a versatile cryogenic micro-photoluminescence setup that is particularly suited to address those questions, at the level of an individual nano-emitter. In particular, we adapted the techniques of super-resolution (as in biology) to this cryogenic environment to directly map the single-photon emitting centers with sub-wavelength (~20 nm) resolution. Quasi resonant excitation spectroscopy complements this approach by providing thorough information about excited confined states.

The goal of this M2 internship proposal is to gain a better understanding of the photophysics of these new heterostructures using these advanced spectroscopic tools. The internship will be a team work with a 3rd year PhD student. Possible developments include the investigation of the spin properties of the ground state of the emitters, opening a vast playground for fundamental physics (building a spin/photon interface for quantum computing) and applications.

Methods and techniques: luminescence micro-spectroscopy, cryogenics, lasers, data analysis and instrumentation (python based)

Possibility to go on with a PhD ? Yes / Envisaged fellowship ? Doctoral school