

2D heterostructures for optical control of individual quantum emitters

Keywords: colloidal quantum emitters, quantum optics, excitons, 2D material, experimental

Scientific context

Single-photon emitters are key building blocks for quantum technologies, including quantum communication, computing and sensing. Their practical implementation requires bright and stable emission, high single-photon purity, and ultimately highly coherent and indistinguishable photons. Integrating quantum emitters into electrically controlled photonic devices is therefore an important challenge.

Several solid-state systems have emerged as promising quantum light sources. Epitaxial quantum dots currently constitute one of the most mature platforms, but their fabrication relies on demanding semiconductor-growth techniques. Colloidal quantum emitters provide a complementary approach: they can be synthesized chemically, their emission wavelength and excitonic properties can be widely tuned through their size, shape and composition, and complex semiconductor heterostructures can be engineered at the nanoscale.

Their optical properties, however, remain strongly influenced by their local electrostatic environment. Charge fluctuations associated with surface states, ligands and the surrounding material can lead to blinking, spectral diffusion and loss of optical coherence. Controlling this environment is therefore an important step towards stable and coherent colloidal quantum light sources.

Goal of the internship:

The main goal of this internship is therefore to provide an electric and electrostatic charge control over individual colloidal nanoplatelets. These objects have an atomically precise controlled thickness, which control the quantum confinement. Being almost two-dimensional they are the well suited material to investigate the influence of the substrate dielectric disorder over the exciton emission energy, as well as they can be easily integrated in 2D heterostructures for larger control.

The successful candidate will participate in several aspects of the project:

1. Synthesis of colloidal semiconducting nanoplatelets and ligand exchange procedure
2. Optical spectroscopy of individual nanoplatelets, including measurements of their photoluminescence energy and stability on different substrates at room and cryogenic temperatures;
3. Fabrication of simple van der Waals heterostructures incorporating colloidal emitters and 2D materials
4. Analysis and physical interpretation of the experimental results

Depending on the progress of the project and the candidate's interests, the internship may also involve photon-correlation measurements and the electrical characterization of gated devices.

Techniques/methods in use: colloidal synthesis, optical spectroscopy of individual quantum emitters, photon correlation measurements

Applicant skills:

We are looking for a M2 student with a strong interest in experimental research at the interface between quantum optics, condensed-matter physics and nanoscience.

Students with backgrounds in condensed-matter physics, quantum physics, nanophysics, chemical physics or related fields are encouraged to apply. Previous experience with optical spectroscopy, 2D materials or colloidal synthesis is welcome but not required.

Curiosity, scientific rigor, enthusiasm for experimental work and a willingness to learn techniques across different disciplines will be particularly valued.

We are committed to providing an inclusive research environment and encourage applications from candidates of all backgrounds.

Industrial partnership: No

Internship supervisor : Antoine Borel – antoine.borel@espci.fr

Internship location: ESPCI – LPEM, 10 rue Vauquelin, 7505 Paris

Possibility for a Doctoral thesis: Yes (Ecole Doctorale)