

Master proposal: deterministic arrays of single-photon emitters in 2D materials using nanoparticles

Join the **2D+ Research Group at CRHEA** on the French Riviera near Nice, France. We are looking for a highly motivated and talented candidate to contribute to pioneering research in quantum nanophotonics with 2D materials. This position offers an exceptional opportunity to engineer, on demand, **arrays of single-photon emitters** in atomically thin semiconductors, a key step towards scalable quantum light sources. The work is conducted within the ANR-funded project NEAR-2D, in close collaboration with the GaN nanostructure growth teams at CRHEA.

Research Focus

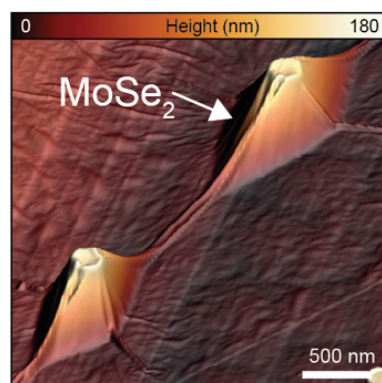
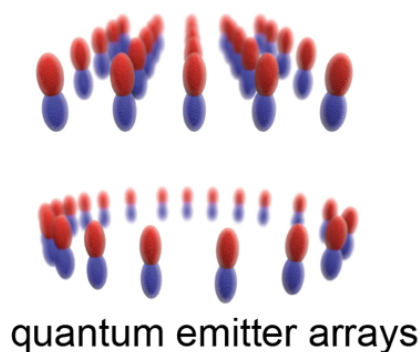
Single-photon emitters (SPEs) are the building blocks of optical quantum technologies. In 2D semiconductors such as WSe₂ and MoSe₂, they appear spontaneously wherever the crystal is **locally strained**: a nanometre-scale bump funnels excitons into a localized state that emits photons one at a time. The consequence is simple and powerful: if we control where the strain is, we control where the emitters are.

The goal of this master's internship is to use **nanoparticles (NPs) as nanoscale strain stamps** to create **deterministic arrays of SPEs**. NPs of controlled size and pitch will be placed on atomically flat hBN, then covered with a transition-metal dichalcogenide monolayer assembled in our FabLab. The intern will image the resulting strain landscape (AFM, Raman, hyperspectral photoluminescence) and identify the emitters with cryogenic micro-photoluminescence and photon-correlation ($g^{(2)}$) measurements. Correlating NP diameter, array pitch and hBN thickness with emitter yield, energy and linewidth will establish the design rules of the platform, benchmarked against the GaN nanopillar arrays grown at CRHEA.

The ultimate ambition is to shrink the array pitch below the emission wavelength, where emitters start to **interact through their near field** and display **collective quantum effects** such as super- and subradiance. Metallic NPs offer a second lever, combining strain with plasmonic Purcell enhancement. This internship can naturally evolve into a PhD project on collective quantum optics in 2D materials.

Facilities and Equipment

Our **state-of-the-art cryo-optics lab** covers 100m² and includes cutting-edge tools such as a fully functional cryostat for **hyperspectral micro-photoluminescence, reflection spectroscopy, time-resolved and single-photon correlation (Hanbury Brown–Twiss) measurements**. We also have a fully equipped **FabLab** dedicated to building custom van der Waals heterostructures, together with atomic force microscopy for nanoparticle positioning and strain mapping. These advanced facilities will enable the intern to contribute to groundbreaking experimental research directly.



Responsibilities

- Conduct in-depth literature reviews, experimental design, and data analysis focused on strain-engineered single-photon emitters in 2D semiconductors.
- Deposit and position nanoparticles on hBN, assemble TMD/hBN heterostructures, and characterize their topography and strain by AFM and Raman spectroscopy.
- Locate and characterize single-photon emitters using cryogenic hyperspectral micro-photoluminescence, time-resolved and photon-correlation measurements.
- Develop a Python analysis pipeline extracting emitter statistics across arrays, and drive the platform towards sub-wavelength arrays for collective quantum optics.

Desired Skills and Qualifications

- **M1** (or equivalent) in physics, photonics, quantum science, or condensed matter.
- **Genuine enthusiasm** for quantum optics, nanofabrication, and hands-on experimental physics.
- **Proficiency in Python**; familiarity with optics alignment, AFM, Arduino, or 3D printing is a plus but not essential.
- **Strong organizational and communication skills**, with a proactive and collaborative approach to teamwork.

Opportunities for Professional Growth

- **Present your research findings** at international conferences and publish in high-impact peer-reviewed journals.
- **Collaborate with leading researchers** in the 2D materials and quantum optics community, at CRHEA, LPCNO (Toulouse), ICFO (Barcelona), and the University of Manchester.
- **Develop hands-on expertise** in a state-of-the-art cryogenic-optics laboratory, acquiring the skills vital for a successful career in quantum photonics or semiconductor physics, whether in academia or industry.

References:

- **Deterministic strain-induced arrays of quantum emitters in a two-dimensional semiconductor.** Branny, A. et al. Nat. Commun. 8, 15053 (2017).
- **Large-scale quantum-emitter arrays in atomically thin semiconductors.** Palacios-Berraquero, C. et al. Nat. Commun. 8, 15093 (2017).
- **Deterministic coupling of site-controlled quantum emitters in monolayer WSe₂ to plasmonic nanocavities.** Luo, Y. et al. Nat. Nanotechnol. 13, 1137–1142 (2018).
- **Quantum nanophotonics in two-dimensional materials.** Reserbat-Plantey, A. et al. ACS Photonics 8, 85–101 (2021).
- **Exponential improvement in photon storage fidelities using subradiance and “selective radiance” in atomic arrays.** Asenjo-Garcia, A. et al. Phys. Rev. X 7, 031024 (2017).

How to Apply

Interested candidates are encouraged to send a CV, cover letter, and academic transcript to Dr. Antoine Reserbat-Plantey (arp@crhea.cnrs.fr). For further details on the project opportunities or other projects in the team, do not hesitate to get in touch.