Master Internship/PhD

Title	**Single Quantum Dot Nano-LEDS using Scanning Tunneling Luminescence**
Location	Laboratoire PMC – Ecole Polytechnique – Route de Saclay – 91128 Palaiseau
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Group website	https://pmc.polytechnique.fr/spip.php?article623&lang=en
Starting date	Early 2026

Colloidal quantum dots (CQDs) are nanoparticles of semiconductor that, due to their size (2-20 nm), fall in the quantum confinement regime. As such, these materials exhibit optical properties that can be continuously adjusted over a wide range of wavelengths, from the infrared to the ultraviolet (Fig. 1a).[1] These objects are very good single photon sources at room temperature, capable of emitting photons one-by-one with high efficiency.[1,2] Recently, diluted CQDs were integrated within electrical transport layers, allowing to observe electrically-injected single-photon emission.[3] Nevertheless, the charge injection pathway is very complex in such devices involving a very large ensemble of CQDs, and brightness is very low as single photon purity is achieved by collecting photons from a very limited area.[4] In this internship, we propose to use scanning tunneling electroluminescence microscopy (STLM)[5,6] to probe electronic and optical properties of CQDs with ultimate resolution down to the atomic scale, essentially realizing a true single-CQD LED inside a STM equipped with electroluminescence collection optics. The goal of this project is three-fold:

(1) probe the local electronic density of state at the single CQD level using to scanning tunneling spectroscopy (STS), correlate such measurements with collected electroluminescence and with ensemble optical spectroscopy;
(2) build a Hanbury-Brown and Twiss interferometer (HBT) and observe single photon emission excited by tunnel currents in single CQDs;
(3) provide an accurate description of the charge injection mechanism.

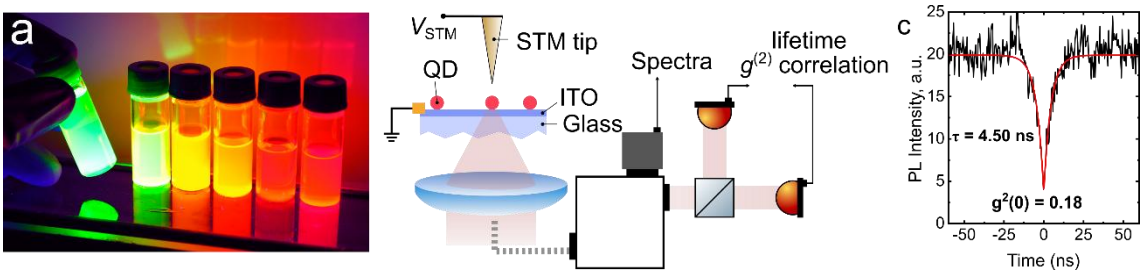

Figure 1. (a) CdSe colloidal quantum dots of different sizes emit at different wavelengths thanks to quantum confinement (b) Principle of STLM single-photon experiment with CQDs. STM tip ensures local injection of current, local electroluminescence is collected in transmission by a lens and spectrally analyzed with an amplified camera. (c) Electrically-injected single photon source purity measurements in a dilute CQD LED device.

The candidate will be trained on all the project steps, from material synthesis to ensemble and single particle characterization, and will perform STLM measurements with the specialists in PMC laboratory. In particular, the candidate will perform:

- Visible and near-IR CQD nanofabrication, material characterization
- Fabrication and optimization of single-particle sample, single particle optical spectroscopy
- Exploration of CQD surface chemistry and sample architecture for STM experiments
- Construction and adaptation of an HBT interferometer compatible with STLM measurements
- Experiment design, automation, data analysis (LabView, Python…)

Candidates with background and/or interest in material science, photonics, inorganic chemistry, nanoscience, optics, condensed matter physics, are welcome to apply.

(1) Pietryga et al. *Chem. Rev.* **2016**, *116*, 10513–10622.
(2) Proppe et al. *Nat. Nanotechnol.* **2023**, *18*, 993–999.
(3) Lin et al. *Nat. Commun.* **2017**, *8*, 1132.
(4) Deng et al. *Nat. Commun.* **2020**, *11*, 2309.
(5) Hahn et al. *Phys. Rev. B* **2018**, *98*, 045305.
(6) Sauty et al. *Phys. Status Solidi B* **2023**, *260*, 2200365.