Master 1 Internship

Perovskite quantum dots coupled to gold gap plasmons

Colloidal lead halide perovskite nanocrystals (NCs) are nanoemitters synthesized via low-cost solution processing, [1] showing a high PL quantum yield and a tunable bandgap. They are currently investigated for a broad range of optoelectronics applications.[2] In particular, they have demonstrated single photon emission with high rates and purity, indistinguishability, making them a promising platform for quantum photonics [3]. However, the optical properties of quantum emitters still have to be improved for integration in quantum photonics devices. For this purpose, the coupling of nano-emitters with plasmonic nanostructures is of great interest and has demonstrated the possibility, for example, of accelerating the emission of quantum emitters, increasing their brightness or changing their radiation pattern. This approach can thus be applied to perovskite NCs [4].

Halide perovskites nanoparticles with the general formula $CsPbX_3$ (X=Br, I) will be studied. The objective of the internship is first to characterize the optical properties of perovskite quantum dots at the single-particle level. In particular, the photon antibunching, brightness and stability of the emitters will be investigated. The candidate will be trained in the use of confocal microscopy and Hanbury-Brown and Twiss (HBT) interferometers for single-photon emission detection.

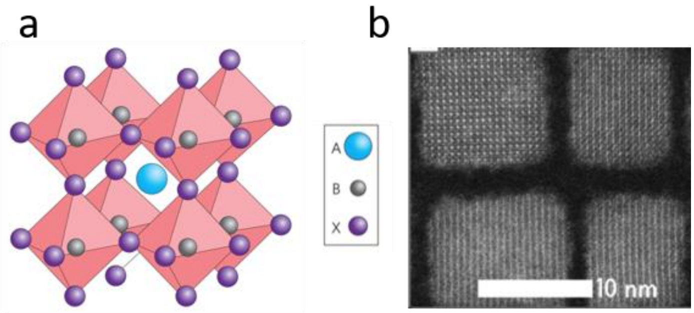

Figure 1 : (a) Perovskite ABX_3 structure (b) HR –STEM image of $CsPbBr_3$ nanocrystals.

Second, the influence of a plasmonic structure on the emission properties will be investigated. A thin polymer layer containing NCs ($CsPbI_3$ in this case) will be deposited on a gold layer and gold nanocubes of a hundred of nanometers will be spin coated on the polymer layer. The gap plasmon appearing in the polymer layer will induce a strong modification of the NC emission. This modification will be experimentally analyzed by comparing with the first experiments performed on single NCs without the plasmonic structure.

These experimental studies can be completed by FDTD numerical simulations to characterize the plasmonic structure and the NC emission modification (decay rate, brightness, radiation pattern…).

Context: GEMaC is a laboratory conducting research in the field of fundamental physics, condensed matter, and material science. The quantum nanophotonics group (https://www.gemac.uvsq.fr/oen) is working on nanoemitters, quantum photon sources, and halide perovskites. The synthesis of the nanoparticles will be performed in collaboration with Cédric Mayer from LuMIn laboratory.

The candidate should have a strong interest in material science and photonics.

References:

[1] Mayer, C. R., Levy-Falk, H., Rémond, M., Trippé-Allard, G., Fossard, F., Vallet, M., Lepeltier, M., Guiblin, N., Lauret, J.-S., Garrot, D. and Deleporte, E. (2022), 'Synthesis of highly calibrated CsPbBr3 nanocrystal perovskites by soft chemistry', *Chemical Communications* **58**(40), 5960--5963.

[2] Dey, A *et al*.(2021), 'State of the Art and Prospects for Halide Perovskite Nanocrystals', *ACS Nano*. **15**(7), 10775—10981

[3] Kaplan, A. E. K., Krajewska, C. J., Proppe, A. H., Sun, W., Sverko, T., Berkinsky, D. B., Utzat, H. and Bawendi, M. G. (2023), 'Hong-Ou-Mandel interference in colloidal CsPbBr3 perovskite nanocrystals', *Nature Photonics* **17**(9), 775--780.

[4] Shuya N., Zhihui L., Shuo W., Naming Z, Bin Y., Xin W. And Fanghui Z (2024) 'Remarkable emission enhancement of CsPbBr3 quantum dots based on an Ag nanoparticle-Ag film plasmonic coupling structure', *Optics Express* 32, 9276

Contacts:

Stéphanie Buil

Stéphanie.buil@uvsq.fr

Damien Garrot

damien.garrot@uvsq.fr