Control of emission from perovskite quantum dots via plasmonic coupling for quantum photonics

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Axis Quantum Nanophotonics (GEMaC, Université de Versailles Saint-Quentin/CNRS, 45 avenue des États Unis, 78035 Versailles)

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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].

Two kind of perovskites will be used for integration in plasmonics devices. First, Halide perovskites nanoparticles with the general formula $CsPbX_3$ (X=Br, I) will be studied. Once the optical properties of perovskite quantum dots have been characterized at the single-particle level (photon antibunching, brightness and stability) with a confocal microscope and Hanbury-Brown and Twiss (HBT) set-up, they will be coupled with plasmonic structures. The GEMaC has developed a technique for manipulating nano-objects with and AFM Tips. It will be then possible to design nanostructures composed of fundamental metallic bricks as gold sphere or cubes with single NC inside.

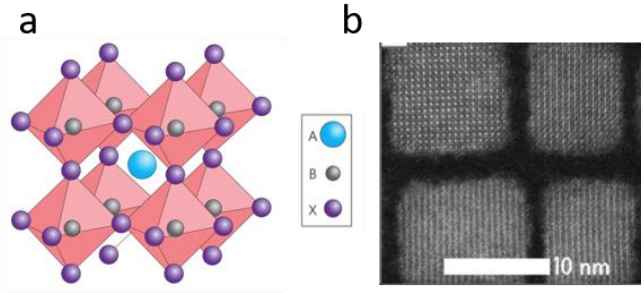

Figure 1 (a) Perovskite ABX_3 structure (b) HR – STEM image of $CsPbBr_3$ nanocrystals.

Second, the influence of a plasmonic structures will be investigated on thin polymer layers containing NCs ($CsPbI_3$ in this case). These layers will be deposited on a gold layer and gold nanometric gold nanoparticules (sphere, cubes, rods..) 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. In the two kind of systems, the modification of the emission will be experimentally analyzed by comparing with the first experiments performed on single NCs without the plasmonic structure. These experimental studies wil be completed by FDTD numerical simulations to characterize the plasmonic structure and the NC emission

modification (decay rate, brightness, radiation pattern..). GEMaC is a laboratory conducting research in the field of fundamental physics, condensed matter, and material science. The quantum nanophotonics group is working on nanoemitters, quantum photon sources, and halide perovskites. The synthesis of the nanoparticles will performed in collaboration with Cédric Mayer from LuMIn laboratory. The candidate should have a strong interest in material science and photonics.

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

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