

Controlling Light Emission from Halide Perovskite Nanocrystals with Plasmonic and Photonic Nanostructures

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Lead halide perovskite nanocrystals (NCs) with the general formula CsPbX_3 ($X = \text{Cl}, \text{Br}, \text{I}$) (Fig. 1) can be synthesized by low-cost solution processing [1]. They combine high photoluminescence quantum yields with a bandgap that can be tuned across the visible, and they are studied for a wide range of optoelectronic applications [2]. Single perovskite NCs are bright single-photon sources with high purity, and their indistinguishability has been demonstrated by Hong–Ou–Mandel interference at cryogenic temperature, which makes them a promising platform for **quantum photonics** [3]. When doped with ytterbium, perovskites can also convert one high-energy photon into two near-infrared photons through quantum cutting, with photoluminescence quantum yields approaching 200% [4]. With an emission lying just above the silicon bandgap, these materials are attractive as spectral down-converters for **photovoltaics**.

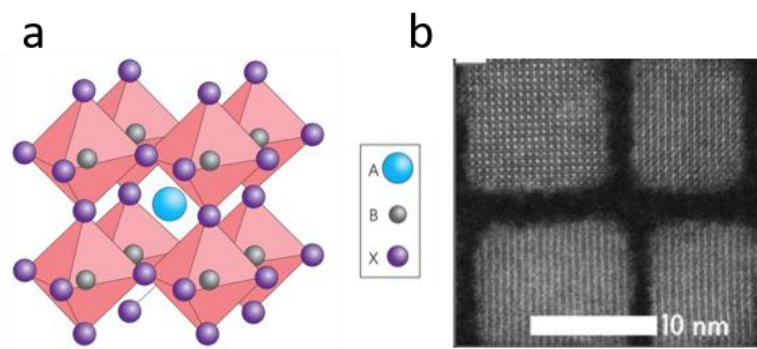


Figure 1: (a) Perovskite ABX_3 structure, (b) HR-STEM image of CsPbBr_3 nanocrystals.[1]

In both applications, the emission of the NCs can be controlled and improved by coupling them to plasmonic or photonic nanostructures. This coupling can accelerate spontaneous emission (Purcell effect), increase brightness and collection efficiency, and change the radiation pattern of nanoemitters [5, 6].

The student will first characterize the emission of bare NCs, both in ensemble and at the single-particle level, using confocal microscopy. This includes emission spectra, recombination dynamics measured by time-resolved photoluminescence, and photon statistics measured with a Hanbury Brown and Twiss set-up. The NCs will then be coupled to plasmonic or photonic structures, such as metallic nanoparticles, metal films with dielectric spacers, or nanoantennas [6]. The changes in decay rate, brightness and emission directivity will be measured. Finite-difference time-domain (FDTD) simulations will support the experiments.

They will be used to design the structures and to estimate the expected Purcell factor, radiative efficiency and radiation pattern.

GEMaC is a laboratory conducting research in the field of fundamental physics, condensed matter, and materials science. The quantum nanophotonics group works on nanoemitters, quantum photon sources, and the photophysics of halide perovskites (<https://www.gemac.uvsq.fr/oen>). The synthesis of the nanocrystals will be carried out in collaboration with other laboratories: LuMIn (ENS Paris-Saclay) and LPEM (ESPCI). The candidate should have a strong interest in materials science and photonics. The internship can be followed by a PhD, through an application to the doctoral school.

References:

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