ParisTech

INSTITUT d'OPTIQUE GRADUATE SCHOOL ParisTech | université PARIS-SACLAY

RESEARCH TOPIC FOR THE PARISTECH/CSC PHD PROGRAM

Field: Physics, Optics ***Subfield***: Nanophotonics

Title: **Exploring the optical properties of perovskite single nanocrystals and superlattices**

ParisTech School: Institut d'Optique Graduate School
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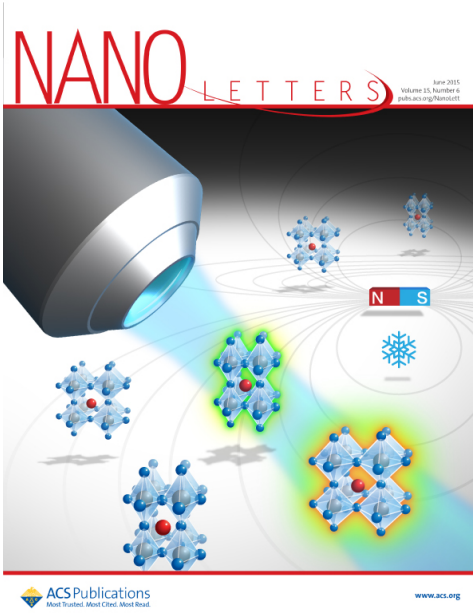
Research group/Lab: LP2N, UMR5298/Nanophotonics group
Lab location: Bordeaux
(Lab/Advisor website): https://sites.google.com/site/bordeauxnanophotonicsgroup/home

Short description of possible research topics for a PhD:

Lead halide perovskites exhibit outstanding optical and electronic properties for a wide range of applications in optoelectronics and for light-emitting devices. Yet, the physics of the band-edge exciton, whose recombination is at the origin of the photoluminescence, is the subject of ongoing debate. In particular, the long-lived ground exciton of lead halide perovskite nanocrystals plays a major role in the quantum properties of the emitted light, since it promotes the formation of biexcitons and thus the emission of correlated photon pairs. Future investigations will aim at reducing the dephasing rate and spectral diffusion in these materials and improve the indistinguishability character of the emitted photons. With a view to the realization of ideal sources of entangled photons, we will aim at achieving degenerate bright triplet emission. We will also study the quantum optical properties of the photoluminescence stemming from lead halide NCs that are self-organized into highly ordered three-dimensional superlattices. We will investigate the spectroscopic and temporal signatures of collective coupling of the nanocrystals, which should give rise to the many-body quantum phenomenon of superfluorescence. Such entangled multi-photon quantum light sources should fuel the development of next-generation devices for quantum technologies.



These activities will be led in close collaboration with the group of chemists of M. Kovalenko (ETH Zürich).

Required background of the student: quantum physics, optics, solid-state physics, lab training.

A list of representative publications of the group:

1. « The ground exciton state of formamidinium lead bromide perovskite nanocrystals is a singlet dark state », P. Tamarat et al. Nature Materials, 18 (2019) 717.
2. « Neutral and charged exciton fine structure in single lead halide perovskite nanocrystals revealed by magneto-optical spectroscopy », M. Fu et al., Nanoletters, 17 (2017) 2895.
3. "Unravelling exciton-phonon coupling in individual $FAPbI_3$ nanocrystals emitting near-infrared single photons", M. Fu et al., Nature Communications, 9, 3318 (2018).
4. « Spectroscopy of Single Nanocrystals», M.J. Fernée, P. Tamarat, B. Lounis, Chem. Soc. Rev. 43 (2014) 1311.