Research Topic for the ParisTech/CSC PhD Program

Field (cf. List of fields below): Physics, Optics
Subfield: Nanophotonics

Title: Exploring the fundamental optical properties of perovskite single nanocrystals

ParisTech School: Institut d'optique Graduate School (LP2N, UMR 5298)
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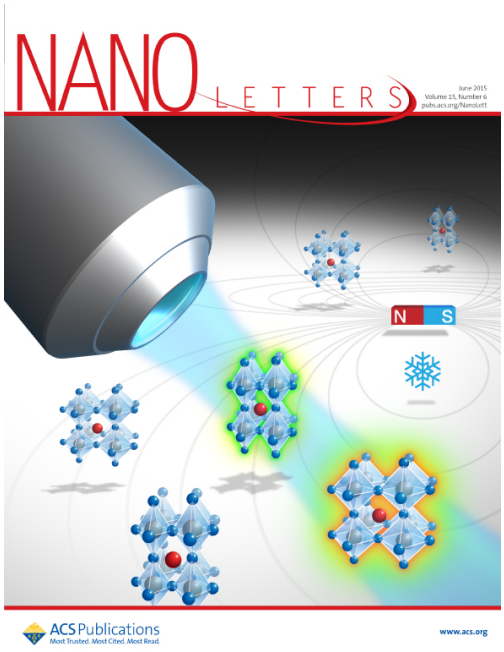
Short description of possible research topics for a PhD:

Recent advances in the colloidal synthesis of strongly emitting lead halide perovskite nanocrystals open up new possibilities for the fabrication of tunable light sources based on the composition and quantum-size-effect tuning, such as light-emitting diodes and lasers, and for the exploration of their potential use as quantum light sources.



The goal of this doctoral work is to explore the properties of the emitting states in perovskite nanocrystals, using magneto-optical spectroscopy and time-resolved spectroscopy of the materials at the single particle level. In particular, we will aim at revealing the spectral fingerprint of the band-edge exciton, which yields precious information on the crystallographic structure of the nanocrystals (that can hardly be obtained with X-ray diffraction methods). The crystal structure is indeed one of the many physical properties that can differ between nanometer-sized and bulk crystalline materials. It also has a major impact on the optical properties of inorganic perovskites and thus on their suitability for photovoltaic or light emitting applications. This study of the fine structure should also shed light on the strength of the Rashba effect in these materials.

We will also explore the exciton-phonon coupling in these nanocrystals, since phonon scattering sets a fundamental intrinsic limit to the charge carrier mobility. This coupling will be extracted from the evolution of the photoluminescence spectra of single nanocrystals with temperature. It will be of prime importance to guide the development of next-generation devices for photovoltaics and for quantum technologies.

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

A list of 5(max.) representative publications of the group: (Related to the research topic)

1. « Neutral and charged exciton fine structure in single lead halide perovskite nanocrystals revealed by magneto-optical spectroscopy », M. Fu et al., Nanoletters, 17 (2017) 2895-2901.
2. "Unravelling exciton-phonon coupling in individual FAPbI3 nanocrystals emitting near-infrared single photons", M. Fu et al., Nature Communications, 9, 3318 (2018).