ARE COLLOIDAL SEMICONDUCTING NANOCUBES EFFICIENT COHERENT EMITTERS?

LABORATORY : Institut Lumière Matière
IN COOPERATION WITH : iLM

LEVEL : M2
TEAM(S) : LUMINESCENCE

CONTACT(S) : HOUEL Julien
MAHLER Benoit

CONTACT(S) DETAILS: julien.houel[at]univ-lyon1.fr / Tel. 0472448338
benoit.mahler[at]univ-lyon1.fr / Tel. 0472431130

KEYWORD(S) : fluorescence / colloidal synthesis / quantum information

SCIENTIFIC CONTEXT :

Colloidal semiconductor nanocrystals are highly versatile light emitters whose size, shape and electronic structure can be engineered through chemical synthesis. Their use as quantum light sources is nevertheless often limited by fluctuations of their local environment, resulting in photoluminescence blinking, spectral diffusion and rapid loss of optical coherence. Developing colloidal emitters that combine high quantum yield, spectral stability and long coherence times therefore remains an important challenge for quantum photonics.

Recently, Peng and co-workers introduced a new family of large, zinc-blende CdSe/CdS core/shell nanocubes operating in the weak-confinement regime. These nanocrystals display remarkable optical properties, including near-unity single-exciton and biexciton photoluminescence quantum yields, strongly suppressed blinking and very narrow emission lines at cryogenic temperature.(1, 2) These results suggest that such nanocubes may provide an unusually clean colloidal platform for investigating optical coherence and approaching the regime of stable quantum-light emission.

Beyond their properties as isolated quantum emitters, cubic nanocrystals are naturally suited to the formation of ordered three-dimensional superstructures. This raises the possibility of using CdSe/CdS nanocubes as building blocks for superfluorescence, Such a phenomenon has been demonstrated in ordered superlattices of lead-halide perovskite (3) .

MISSIONS :

The objective of this project is to develop cubic CdSe/CdS nanocrystals with controlled confinement and heterostructure architecture, and to investigate their optical properties from the single nanocrystal level to collectively coupled assemblies.

A first objective will be to reproduce and adapt the synthesis of weakly confined CdSe/CdS core/shell nanocubes inspired by the work of Peng and co-workers. The nanocrystals will be characterized by electron microscopy, absorption and photoluminescence spectroscopy and time-resolved photoluminescence. Their size, morphology and heterostructure will be correlated with their excitonic properties.

If time allows it, cryogenic single nanocrystal emission experiments will be carried out to directly measure the optical coherence of these nanocrystals emission.

OUTLOOKS :

The project may be continued as a PhD, subject to funding (doctoral school fellowship).

BIBLIOGRAPHY :

1- Lv, L., et al. JACS, 144(37), 16872–16882. https://doi.org/10.1021/jacs.2c05151

2- Ye, Y., et al (2024). Nano Letters, 24(9), 2712–2718. https://doi.org/10.1021/acs.nanolett.3c04250

3- Rainò, G., et al. (2018). Nature, 563(7733), 671–675. https://doi.org/10.1038/s41586-018-0683-0

published on 06/10/2026