SCIENCES SORBONNE UNIVERSITÉ

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PhD thesis proposal

INSP INSTITUT DES NANOSCIENCES DE PARIS

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Exciton transfers and collective fluorescence effects from self-assembled nanoparticles

Keywords: nanosciences, fluorescence, optical microscopy, exciton interactions

The **group *Nanostructures and Optics* at INSP** studies light emission and propagation at the nanoscale : fluorescent nano-sources, emission control by photonic crystals or plasmonic nano-antennas, chirality of fluorophores and antennas, bio-inspired photonic crystals etc. Among our interests, fluorescent semi-conductor nanoparticles are very bright, stable and versatile light sources with more and more applications in bio-imaging, lighting and TV displays, and possibly for photovoltaics. When a ***single* nanoparticle** is examined by **fluorescence microscopy**, its emission often displays purely quantum-optical properties such as **single photon emission** (photons are emitted one by one) which can be used for quantum information.

While fluorescence from isolated emitters is now well known, most opto-electronic applications (LEDs, solar cells…) involve nanoparticles packed in a dense layer, where they should behave very differently because of **short-range interactions, charge transport and exciton diffusion between neighboring particles**. By using adequate solvent and ligands, the group of B. Abécassis in ENS Lyon has managed to self-assemble chains of hundreds of semiconductor nanoplatelets (fig. 1(a-c)) which constitute a good model system for nanoparticles interactions. We have shown that, due to near-field dipole-dipole Förster-type interactions (FRET), excitons migrate extremely fast between platelets (fig. 1(d)) so that the **fluorescence behavior of assembled platelets is expected to show collective effects** instead of only being the sum of the luminescence of each platelet.

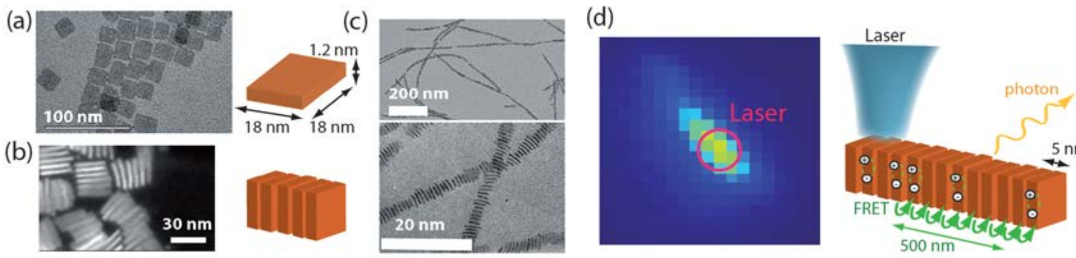

Figure 1 : TEM images of (a) CdSe nanoplatelets, (b) aggregated platelets and (c) self-assembled stacked nanoplatelets [S. Jana et al., Science Advances 2017]. (d) Previous result : a laser excites a spot on the chain and energy propagates by FRET between around 100 platelets so that a 1-µm portion radiates light [Jiawen Liu et al., Nano Lett. 20, 3465 (2020)].

The **aim of the PhD wor**k is to determine

- how the assembly geometry affects the FRET exciton transfers,
- to which extent FRET induces collective fluorescence effects (intensity fluctuations, multi-excitonic effects),

- and whether this ensemble of light emitters can show enhanced radiation by nano-lasing or by interfering constructively with each other (superradiance).

We will examine different configurations of emitters assembly : chains of different platelet distances, platelets with chiral ligands, nanorods assembled by liquid crystals. In order to optimize light-matter coupling, the assembled particles will be coupled to plasmonic nano-antennas.

References (previous work in the group) :

Fu Feng et al., ACS Photonics 5, 1994 (2018)
Fu Feng et al., Nano Research 11, 3593 (2018)
Jiawen Liu et al., Nano Lett. 20, 3465 (2020)
Jiawen Liu et al., ACS Photonics (2020)

Techniques/methods in use: Photoluminescence microscopy, spectroscopy, polarization analysis, single-photon detection
Applicant skills: Motivation for experimental work, organization, knowledge in optics

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