2021-2022

Master thesis proposal

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Title:

Nanoscale cinematography of reconfigurable plasmonic assemblies

Keywords:
Liquid-phase TEM, Super Crystals, self-assembling

Scientific description:

Context: An important challenge to develop plasmonic assemblies (i.e. supercrystals) with tunable properties is to control the distance between gold nanoparticles (NPs) to handle regions of intense optical activity at the interparticle gap. Different external stimuli actuating a broad range of nanoscale forces can be manipulated to achieve this goal.[1] Among these, depletion forces can be used to induce self-assembly of plasmonic gold NPs in a reversible manner. In this case, the surfactant micelles induce NPs flocculation by excluded volume interaction and the NPs can be redispersed upon dilution. The potential of Liquid-Cell Transmission Electron Microscopy (LCTEM) to observe the crystalyzation pathway and stability of supercrystals was recentlty revealed.[2] In this internship, we propose to exploit this unique way to visualize supercrystals behavior in real time with single NP sensitivity to study dynamical processes driven by depletion forces.

Objectives: We will use LCTEM on the SuperTEM available at the MPQ lab (University of Paris). This unique in situ TEM instrument allows observing the dynamics of individual nanostructures in various liquid environments of controlled composition and temperature.[3] High speed imaging will be exploited to study how the structure and lattice parameter of supercrystals vary under various controlled stimuli and also to reveal their redispersion processes (see figure).

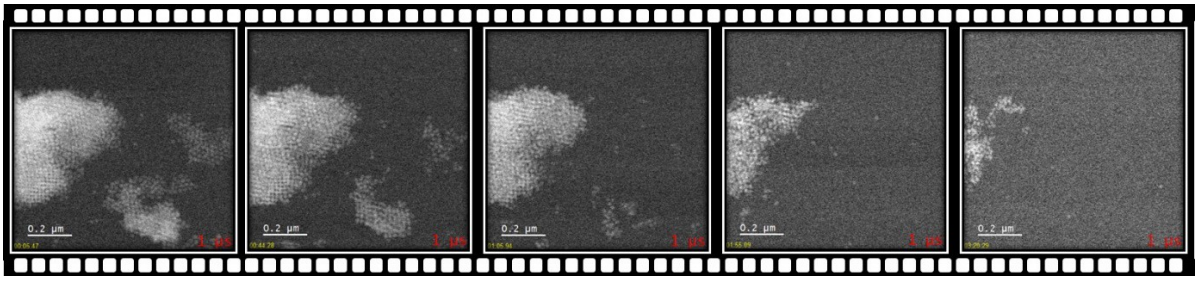

Figure: Destabilization of 2D and 3D supercrystals made of 8 nm NPs monitored in toluene with the SuperTEM.

NP fabrication and in situ TEM investigations will be performed in close collaboration with Cyrille Hamon from the Laboratoire de Physique des Solides at Paris Saclay University. We will work with gold nano-triangles to study the effects of the following external stimuli on supercrystals dynamics: (i) the surfactant concentration, (ii) the temperature, (iii) the electrostatic repulsion. Analysed with advanced video processing methods, such nanoscale cinematography will be a major asset to quantitatively understand NP interaction in large assemblies and compare unprecedented experimental data with theoretical models.

More importantly, the interdisciplinary skills in physics, chemistry, electron microscopy and data anaysis that will be acquired by the future candidates will facilitate his professional insertions.

References:

1. Bishop, K. J. M.et al. Small 2009, 5, (14), 1600-1630.
2. Ou, Z. et al. Nat. Mat. 2020, 19, 450.
3. Khelfa, A. et al. Advanced Materials 2021, 2102514.

Techniques/methods in use: liquid-phase transmission electron microscopy, video proccessing, modelization.

Applicant skills: Good knowledge of materials science and/or solid-state physics (knowledge in electron optics and image processing will be major assets). Strong motivation to perform in a multidisciplinary environment at the frontier of physics and chemistry. Autonomy, collaborative spirit, oral and writing skills in French or in English

Applications in English or in French should include:

- A short cover letter.
- Names and contact information of at least one reference.
- Up-to-date CV with education history and any research experience.
- Copy of university marks at the bachelor and Master levels.

Industrial partnership: N

Internship supervisor(s)
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Internship location: Laboratoire MPQ, Université de Paris, Paris 13e

Possibility for a Doctoral thesis: Y (EDPIF competition)