'Physique et Chimie des Matériaux' – ED 397 – année 2022

PhD project for funding, to send by 28/02/2022 to

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Research unit (full name + acronym) : Institut des Nano-Sciences de Paris

Team if applicable : Physico-chimie et dynamique des surfaces

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Nber of phD under supervision 1 Participation to supervisor training? no Year

Co-supervisor : HDR? select Position : select

Tel email :

Research unit :

International co-supervision ? select

Keyword 1 : nanoparticles Keyword 2 : optical properties

Keyword 3 : topological defects Keyword 4 : liquid crystal

Select co-funding programme if applicable : select

Project title : Advanced superstructures of nanoparticles in liquid crystal topological defects

Project Description :

The objective of this thesis is to build advanced superstructures of nanoparticles (NPs) in liquid crystal (LC) matrices and investigate their structure and optical properties. In our group at INSP, we pointed out how to create a thin LC film made of a large array of oriented topological defects [1, 2]. A self-assembly process for the NPs is driven by the confinement of the NPs in the topological defects of the LC film [3]. This leads to formation of strictly oriented NP chains [3-4] or 2D networks of NPs of different localization in the LC matrix [5]. Since it is known that NP optical properties are controlled by their specific orientation [4, 6] and by the NP-NP electromagnetic coupling induced by their organization [3-5,7], the purpose of the PHD will be to study how to play both on the NP specificities and on external parameters, in order to obtain new kinds of NP optical property activations.

- We will firstly prepare composites made of different kinds of NPs. We will modify size, shape (nanospheres and nanorods) and nature (gold plasmonic and fluorescent NPs including perovskites…) of the NPs. Depending in particular on the NP size, 1D chains or 2D networks will be favoured. As a result we may create composites with various coexisting optical properties, e.g. different wavelengths of light emission, each one corresponding to a specific localization and a specific NP organization in the LC matrix. We will also appropriately choose size, shape and nature of two kinds of NPs in order to induce electromagnetic coupling between different kinds of NPs either within the NP chains or within the 2D network or between 1D chains and 2D networks. For example using metallic and fluorescent NPs we will modulate the optical interaction (the so-called Purcell effect) as a function of the NP organization. This will allow not only to obtain new kind of NP optical properties but also to deeply study the influence of NP-NP electromagnetic coupling on these properties

thanks to the well-defined structure of each NP organization [3].

- We will secondly focus not on the modification of the NPs but on the modification of the LC matrix structure. This will be achieved thanks to the sensitivity of the LC matrix to electric field, magnetic field and temperature. Electric field will allow for a rotation of the topological defects, thus to a rotation of the NP organizations. In presence of magnetic nanoparticles, oscillating magnetic field will lead to a local modification of the topological defect cores for a local modification of the NP organization. Temperature increasing above smectic/nematic transition will allow for a reversible disappearance of the defects for a reversible disordering/ordering of NP networks that may lead to a reversible modification of the optical properties. A large number of activation of the NP organizations, consequently of the NP optical properties under external parameters will thus be obtained and studied.

The PHD work will be associated with a large number of experimental measurements, X-ray scattering at synchrotron, optical microscopy, UV-visible spectrophotometry, fluorescence microscopy and spectroscopy, AFM, etc... We will also strongly collaborate with a number of theoreticians. This will be mostly with slovenian and american (Philadelphia and Chicago) collaborators concerning theoretical investigations of liquid crystals. We will also simulate the optical properties of the nanoparticles under strong electromagnetic coupling together with INSP colleagues.

[1] D. Coursault et al., Soft Matter 12 (2016) 629
[2] B. Zappone and E. Lacaze, Liq. Cryst. Rev., submitted (2022).
[3] D. Coursault et al., ACS Nano 9 (2015) 11678
[4] B. Rozic et al., ACSNano 11 (2017) 6728
[5] S-P Do, Nano Letters 20 (2020) 1598
[6] L. Pelliser et al., Adv. Funct. Mat. 25 (2015) 1719
[7] I. Gharbi et al., ACS Appl. Nano Mat. 4 (2022) 6700