SINGLE NANOSTRUCTURES UNDER EXTREME PRESSURES: METALLIC NANOPARTICLES, CARBON NANOTUBES & 2D MATERIALS

LABORATORY : Institut Lumière Matière

LEVEL : M2
TEAM(S) : FEMTO-NANO

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SCIENTIFIC CONTEXT :

The FemtoNanoOptics group in Institut Lumière Matière (iLM in Lyon) has been a pioneer in the quantitative measurement of the absorption cross section of nanoscale single objects, with an original technique called spatial modulation spectroscopy [1]. Addressing a single nanoparticle with diffraction limited laser beams allows for overcoming the inhomogeneities observed in ensembles. Over the years, the roles of intrinsic quantum confinement effects and extrinsic environment effects have been unveiled on nanostructures such as metal nanoparticles and carbon nanotubes [2].

Recently, the group conceived and implemented a unique experimental setup based on a miniature diamond anvil cell to perform spatial modulation spectroscopy under high hydrostatic pressure (up to 10^5 atm). Under these extreme conditions, the shape and the structure of nanostructures can be heavily modified, leading to deep alterations of their physical properties related both to the ionic lattice and the electronic cloud. We applied this technique to study for the first time the optical absorption of single metallic nanoparticles under high pressure [3].

MISSIONS :

This master/thesis project consists in extending this previous work to novel original nanostructures with different dimensionalities: metal nanoparticles with exotic shape or core/shell structure, carbon nanotubes and 2D materials such as graphene, hBN and their stacks. The complex interplay of interface and volume atoms will be explored by comparing these nanostructures. Beyond the basic physics understanding, their implementation as pressure probe resolved at the nanoscale will be tested, using for instance the shift of the plasmonic resonance of the metallic nanoparticles or the radial collapse of the nanotubes. This will allow unprecedented study of the non-hydrostaticity of fluids at high pressure.

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OUTLOOKS :

The internship can be extended into a PhD.

BIBLIOGRAPHY :

[1] Animation movie on the Spatial Modulation Spectroscopy technics on the group homepage

[2] A.Crut et al. Chem. Soc. Rev. 43 :3921–3956 (2014) ; J.C. Blancon et al., Nature Comm. 4, 2542 (2013)

[3] F. Medeghini et al., ACS Nano 12(10):10310-10316 (2018)

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