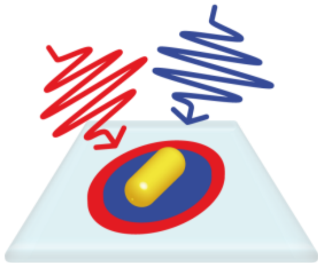
Master Internship / PhD proposal (year 2020-2021)



Host team

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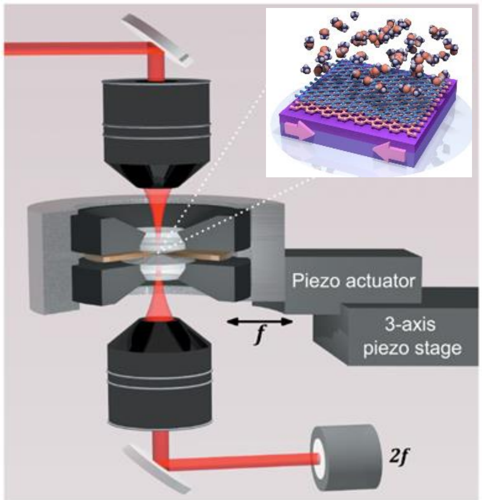
Project title

Optical response of a single nanostructure – nanoparticle, nanotube, 2D material – under extreme pressure conditions

Keywords

optics, nanoscopy, high pressure, diamond cell, femtosecond laser, nanoparticles, carbon nanotubes, graphene, 2D materials

The FemtoNanoOptics group in Institut Lumière Matière (iLM) 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].



Diamond anvil cell coupled to a spatial modulation microscope, which allows to quantitatively measure the absorption of single nanostructures (here bilayer graphene) under extreme conditions [3].

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 GPa). Under these extreme conditions, the shape and the structure of nanostructures can be heavily modified, leading to deep alterations of their physical properties. We applied this technique to study **for the first time the optical absorption of single metallic nanoparticles under high pressure** [3].

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, 2D materials such as graphene, hBN and their stacks. For instance, this study is of strong importance in the case of carbon nanotubes since ensemble measurements already evidenced that high hydrostatic pressure can induce a radial collapse. In the case of a stack of 2D materials, the structural anisotropy will lead to an original orthogonal strain (compared to usual isotropic induced strain) that had never been explored.

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This internship can be extended into a PhD.

[1] Animation movie on the Spatial Modulation Spectroscopy technics on the group homepage
[2] J.C. Blancon *et al.*, Nature Comm. 4, 2542 (2013); A.Crut *et al*. Chem. Soc. Rev. 43 :3921–3956 (2014)
[3] F. Medeghini *et al.*, ACS Nano 12(10):10310-10316 (2018)