MASTER PHYSIQUE ET APPLICATIONS

Master 2 Dispositifs Quantiques

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Internship offer

Laboratory: Laboratoire Matériaux et Phénomènes Quantiques (UMR 7162)
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Charge and spin transport through 2D van der Waals heterostructures inserted in cavity

The control of the electronic properties of solids is one of the main challenges of condensed matter physics. In recent years, 2D van der Waals materials such as graphene and transition metal dichalcogenide monolayers and their heterostructures have sparked a tremendous interest for their tunable physical behavior associated to the electron's quantum degrees of freedom including spin, valley and layer pseudospin[1]. New opportunities to control their properties are emerging thanks to optical microcavities, and TeraHertz electromagnetic resonators such as nanoplasmonic split-ring structures with deeply sub-wavelength modal confinement and strongly enhanced light-matter interaction[2]. Recent studies have shown that microcavities can modify not only the optical response of electronic materials, but also the transport properties even in the absence of illumination[3,4]. Indeed, the ultrastrong light-matter coupling has the potential to dress electrons and affect charge and potentially spin conduction.The general goal of this internship/PhD is to experimentally explore the fundamental electronic and spintronic properties of van der Waals materials controlled by electromagnetic cavity resonators.
For this internship, we are looking for a highly motivated student to implement in our lab a cavity-based technology for electronic and spintronic devices. The propagation of charge and spin through the heterostructure will be studied in the standard DC regime. The intern will be in charge of the nanofabrication, the characterization and the measurements of the devices.

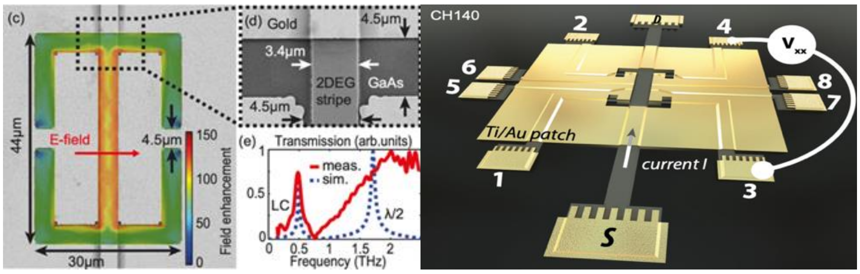

Fig.1. Left panel: a metallic split-ring resonator with deeply subwavelength confinement of an electromagnetic Terahertz LC mode embedding a 2D electron gas in GaAs. Right panel: a set-up for transport measurement through a 2D electronic system embedded in a complementary split-ring resonator (metal around the split-ring structure). Taken from [3].

1. Geim, A. K. & Grigorieva, I. V. Van der Waals heterostructures. Nature 499, 419–25 (2013).
2. Carusotto, I. & Ciuti, C. Quantum fluids of light. Rev. Mod. Phys. 85, 299–366 (2013).
3. Paravicini-Bagliani, G. L. et al. Magneto-transport controlled by Landau polariton states. Nat. Phys. 15, 186–190 (2019).
4. Latini, S., Ronca, E., De Giovannini, U., Hübener, H. & Rubio, A. Cavity Control of Excitons in Two-Dimensional Materials. Nano Lett. 19, 3473–3479 (2019).

Methods and techniques: micro and nanofabrication in clean-room environment, structural characterizations by atomic force microscope, electrical transport and magnetotransport measurements from 1K to 300K.

Possibility to go on with a PhD ? Yes
Envisaged fellowship ? EDPIF