

Master 2: International Centre for Fundamental Physics

INTERNSHIP PROPOSAL

Laboratory name : Matériaux et Phénomènes Quantiques – MPQ UMR7162

Location : Université de Paris – 10 Rue A. Domon et L. Duquet – Bât. Condorcet – 75013 PARIS

Internship director : Cristiano Ciuti (THEORIE group)

@mail : cristiano.ciuti@u-paris.fr

Tel : +33 (01) 57 27 62 37

<https://www.mpq.univ-paris-diderot.fr/?Cristiano-Ciuti>

<https://scholar.google.com/citations?user=rzc1ND0AAAAJ&hl=en>

<https://publons.com/researcher/2684340/cristiano-ciuti/>

Theory of cavity-mediated quantum electronic materials

In the presence of ultrastrong light-matter interaction [1], electrons can be “dressed” by intense electromagnetic vacuum fields and, as a result, the properties of materials can be dramatically altered. Such giant vacuum fields can be achieved for instance via extreme spatial confinement of electromagnetic modes in nanoplasmonic resonators. Thanks to the extreme coupling to such vacuum fields, the electron transport in cavity-embedded materials can be dramatically changed even *without* illumination [2,3,4]. Several fascinating problems are emerging in the scientific community, particularly those concerning the role of virtual photons and vacuum fields on cavity-mediated superconductivity, cavity-controlled excitons and cavity-induced topological materials.

In this internship that can be followed by a PhD thesis, the Master student will learn state-of-the-art theoretical techniques on cavity QED, condensed matter and manybody quantum theory. The goal of the internship will be to explore theoretically new directions in this exciting field, such as cavity-mediated electronic properties in the new class of 2D materials (graphene, twisted bilayer graphene, TMD materials, ...) including cavity-induced excitons and cavity-mediated superconductivity.

[1] For recent reviews, see P. Forn-Diaz et al., **Rev. Mod. Phys.** 91, 025005 (2019) ; A. F. Kockum et al., **Nature Reviews Physics** 1, pages 19–40 (2019).

[2] N. Bartolo, C. Ciuti, *Vacuum-dressed cavity magnetotransport of a two-dimensional electron gas*, **Phys. Rev. B** 98, 205301 (2018).

[3] G. L. Paravicini-Bagliani, F. Appugliese, E. Richter, F. Valmorra, J. Keller, M. Beck, N. Bartolo, C. Rössler, T. Ihn, K. Ensslin, C. Ciuti, G. Scalari, J. Faist, *Magneto-transport controlled by Landau polariton states*, **Nature Physics** 15, 186–190 (2019).

[4] C. Naudet-Baulieu, N. Bartolo, G. Orso, C. Ciuti, *Dark vertical conductance of cavity-embedded semiconductor heterostructures*, **New J. Phys.** 21 093061 (2019).

Condensed Matter Physics : YES

Quantum Physics : YES

Macroscopic Physics and complexity : YES

Theoretical Physics : YES