# *INTERNSHIP PROPOSAL M1/M2*


Laboratory name: Center for Nanoscience and Nanotechnology
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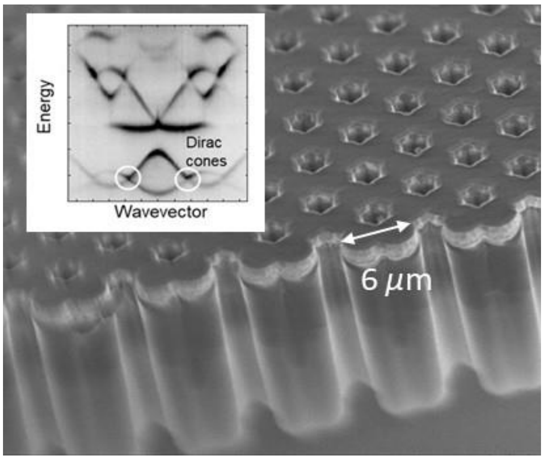
Thesis possibility after internship: YES
Funding: YES Type of funding: Doctoral School, Research contracts (to be discussed)

## Topological physics with light in semiconductor lattices

The discovery of topological phases of matter (e.g. quantum Hall effect, topological insulators…) in the 1980s has led to a profound revolution in solid-state physics. Recently, the extension of these exotic phases to photonic systems (e.g. photonic crystals, coupled resonators, micro-structured waveguides…) has enabled a much wider and easier exploration of topological concepts, thanks to the versatility of these synthetic platforms. The present scientific project aims at extending even further the frontiers of this field of topological photonics by using cavity polaritons. Polaritons are light-matter mixed particles resulting from the strong coupling between quantum well excitons and photons confined in a cavity. Their advantages over pure photons arise from their excitonic part that allows for: i) exploring nonlinear physics (e.g. solitons, lasing…), and ii) realizing time-reversal broken topological phases similar to the quantum Hall effect using their response to magnetic field.

Taking advantage of the technological facilities available at C2N, our group has developed state of the art semiconductor lattices where polariton band structures can be engineered with well-defined topological properties. For example, honeycomb lattices (i.e. artificial graphene) have been implemented and show robust edge states associated to their non-trivial topology, as well as a garden variety of exotic phenomena emerging from the topological properties of Dirac cones. Furthermore, taking advantage of the nonlinear properties of polaritons, we recently demonstrated the first topological laser where the resonating mode is protected against perturbations of its environment by the topology of the underlying lattice.




*Electron microscopy image of a honeycomb lattice of semiconductor resonators, which emulate graphene physics. Inset: band structure measured by optical spectroscopy revealing characteristic Dirac cones.*

During the internship and the following PhD, the candidate will explore polariton fluids in novel architectures of lattices with the overall objectives of discovering new and non-trivial topological properties. The work will be divided in two main parts: an experimental one with low temperature optical spectroscopy under strong magnetic fields, and a more theoretical one to evaluate the topological properties of different lattice geometries.


[1] Quantum Fluids of Light, I. Carusotto and C. Ciuti, Rev. Mod. Phys. 85, 299 (2013).
[2] Lasing in topological edge states of a one-dimensional lattice, P. St-Jean et al., Nat. Photon. 11, 651 (2017)
[3] Measuring topological invariants in polaritonic graphene", P. St-Jean et al., arXiv:2002.09528 (2020)
[4] Driven-dissipative solitons in topological lattices, N. Pernet et al., to appear on Arxiv