Title: *Synthetic Polariton Matter: Hamiltonian Tomography and Optical Nonlinearities*

Abstract:
Exciton-polaritons are hybrid quasiparticles arising from strong coupling between cavity photons and excitons in semiconductor quantum wells [1]. They offer a versatile platform for engineering synthetic photonic materials with tailored properties. In this talk, I will present recent progress in the design and characterization of polariton lattices, where microcavity pillars are arranged into 1D or 2D arrays to implement tight-binding Hamiltonians.

I will first present a method for Hamiltonian engineering based on the patterning of coupled microcavities, and explain how this allows full control over the lattice geometry and hopping parameters. I will focus on a recently developed measurement technique that enables full reconstruction of the Bloch Hamiltonian, by analyzing the momentum-resolved emission spectra from the lattice. This optical tomography technique provides access to every Bloch mode across the entire Brillouin zone, and enables us to experimentally explore the quantum geometry and topology of polariton lattices.

In the second part of the talk, I will explore how polariton-polariton interactions can be harnessed in such systems [1]. By exploiting the matter component of polaritons, we introduce interaction-induced control over the onsite energies. I will show how this enables the all-optical introduction of a vacancy in a Su–Schrieffer–Heeger (SSH) chain, creating a nonlinear interface for Bogoliubov excitations [2]. This result illustrates how interactions can lead to the emergence of new nonlinear topological phases in driven-dissipative systems [3].

These advances demonstrate the potential of polariton platforms to probe and control synthetic photonic materials.

[1] I. Carusotto, and C. Ciuti, Rev. Mod. Phys. **85**, 299 (2013)
[2] Nicolas Pernet, *et al.*, Nature Physics **18**, 678 (2022)
[3] D. Solnyshkov, *et al.*, Optical Materials Express **11**, Issue 4, 1119 (2021)

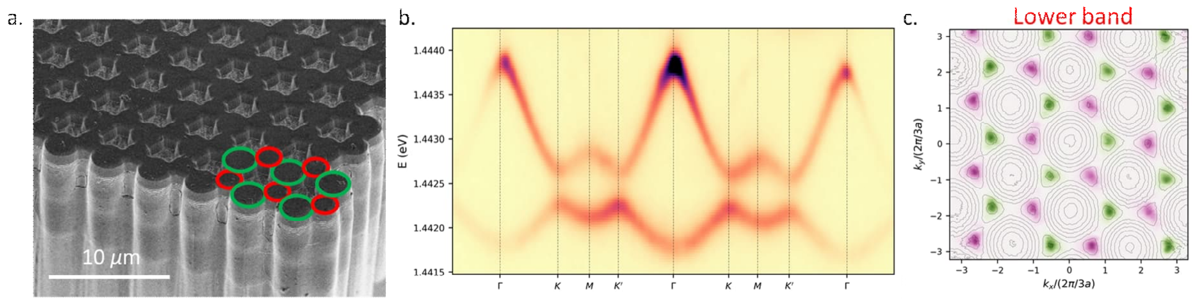

Figure: FIG. 1. a. SEM image of a polariton honeycomb lattice, implementing a "photonic h-BN lattice". b. Measured band structure, and c. experimentally reconstructed Berry curvature.

Sylvain Ravets is a CNRS research scientist at the Centre for Nanosciences and Nanotechnology (C2N, CNRS / Université Paris-Saclay, France). His work explores hybrid light-matter systems, with a focus on engineering exciton-polaritons in semiconductor microcavities to study topological and quantum phenomena in synthetic photonic lattices. He earned his Ph.D. in physics in 2014 through a joint program between the Joint Quantum Institute (University of Maryland) and the Institut d'Optique, working on quantum engineering with cold atoms. He then joined ETH Zurich as a postdoctoral fellow, where he investigated solid-state quantum optics in the Institute of Quantum Electronics. Since joining CNRS in 2018, he has led an experimental program at the intersection of nanophotonics and quantum materials. He was awarded an ERC Starting Grant in 2020.