Quantum fluids of light in semiconductor lattices

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Semiconductor microcavities appear today as a powerful platform for the study of quantum fluids of light. They enable confining both light and electronic excitations (excitons) in very small volumes. The resulting strong light-matter coupling gives rise to hybrid light-matter quasi-particles named cavity polaritons. Polaritons propagate like photons but strongly interact with their environment via their matter part: they are fluids of light and have been shown to exhibit fascinating properties such as superfluidity or nucleation of quantized vortices. Sculpting microcavities at the micron scale, it is possible to engineer lattices of various geometries and use this photonic platform for the emulation of different Hamiltonians.

I will illustrate with some examples the potential of this non-linear photonic platform for quantum simulation. Polariton lasing can be triggered in the topological edge states of a 1D SSH chain, with robustness to disorder related to the underlying topology. Quasi periodic lattices have shown fractal energy spectrum and edge states related to structural topological invariants. Finally honeycomb lattices of coupled cavities reveal Dirac physics and new edge states related to high energy modes emulating p orbitals. When controlling the interplay between pump, on-site nonlinearity and dissipation, this photonic platform opens the way to the exploration of complex non-linear dynamics, non-linear topological physics and in a near future quantum many body physics with light.

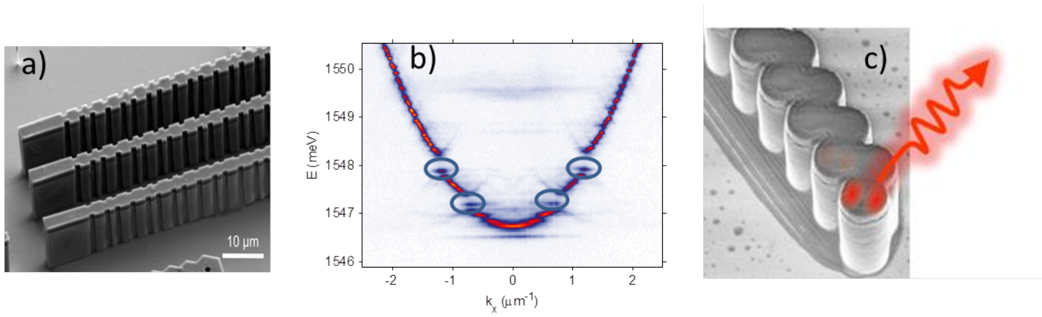

Figure 1. a) Scanning electron microscopy (SEM) image of a 1D polariton quasi-crystal; b) Measured polariton far field emission in a 1D quasi-crystal: a fractal band structure is observed with edge states (encircled); c) SEM image of a 1D SSH chain of coupled micropillars with schematic representation of polariton lasing in a topological edge state.

[1] F. Baboux et al., PRB 95, 161114(R) (2017)
[2] M. Milicevic et al., Phys. Rev. Lett. 118, 107403 (2017)
[3] P. Saint Jean et al., Nature Photonics 11, 651 (2017).