MANIPULATING POLARITON QUANTUM FLUIDS IN SEMICONDUCTOR MICROCAVITIES

Jacqueline Bloch
Laboratoire de Photonique et de Nanostructures, LPN/CNRS
Route de Nozay, 91460 Marcoussis, France
Jacqueline.bloch@lpn.cnrs.fr

At the frontier between non-linear optics and Bose Einstein condensates, semiconductor microcavities have opened a new research field, both for fundamental studies of bosonic quantum fluids in a driven dissipative system, and for the development of new devices for all optical information processing. Optical properties of semiconductor microcavities are governed by bosonic quasi-particles named cavity polaritons, which are light-matter mixed states. Cavity polaritons propagate like photons, but interact strongly with their environment via their matter component. Patterning of semiconductor microcavities on a micron scale allows confining polaritons in photonic circuits or in lattices.

After a general introduction on cavity polaritons, I will illustrate the diversity of physical problems that can be addressed in this non-linear photonic system using patterned microstructures.I will show that taking advantage of the giant non-linearities induced by polariton interaction it is possible to realize photonic circuits in which coherent polaritons are propagated and optically manipulated.

The second part of the talk will be dedicated to the physics of polaritons in lattices. I will show that we can implement complex Hamiltonians and thus develop a new platform for quantum emulation. For instance, we have demonstrated a fractal energy spectrum for polaritons by engineering a quasi-periodic lattice. It becomes possible to explore the physics of non-linear wavepackets in such complex environment. Polaritons are also very promising for the investigation of graphene physics using honeycomb lattices. For instance, Dirac cones are directly imaged in the polariton far field emission. Finally we recently fabricated lattices holding non dispersive bands. In such flat bands, kinetic energy frustration dramatically modifies the spontaneous spatial coherence of polariton condensates.

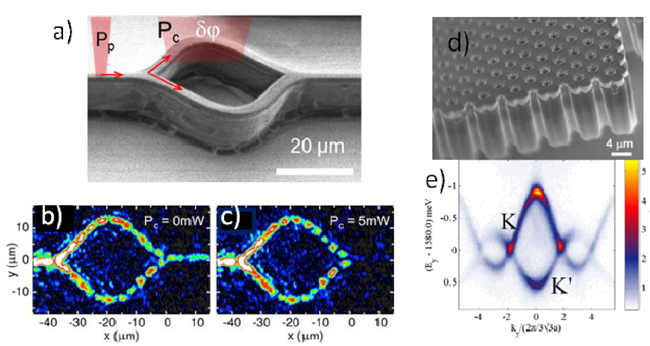

Fig: a) Scanning electron miscroscope image (SEM) of a polariton interferometer; b) and c) : emission measured in real space showing how the transmission of the polariton interferometer can be optically controlled; d) SEM image of a honeycomb lattice of micropillars; e) Polariton dispersion measured in the honeycomb lattice: Dirac cones are directly evidenced.

[1] *Spontaneous formation and optical manipulation of extended polariton condensates*, E. Wertz, et al., **Nat. Phys**. 6, 860 (2010)
[2] *Realization of a double barrier resonant tunneling diode for cavity polaritons,* H-.S. Nguyen et al., **Phys. Rev. Lett**. 110, 236601 (2013)
[3] *All-optical phase modulation in a cavity-polariton Mach-Zehnder interferometer*, C. Sturm et al., **Nature Commun**. 5, 3278 (2014)
[4] *Fractal energy spectrum of a polariton gas in a Fibonacci quasi-periodic potential*, D. Tanese et al., **Phys. Rev. Lett.** 112, 146404 (2014)
[5] *Direct observation of Dirac cones and a flatband in a honeycomb lattice for polaritons*, T. Jacqmin et al., **Phys. Rev. Lett.** 112, 116402 (2014)