Centre de Nanosciences et de Nanotechnologies

Soutenance de thèse

Jeudi 12 mars

14h00
Centre de Nanosciences et de Nanotechnologies
10 boulevard Thomas Gobert
91120 Palaiseau
Amphithéâtre

Nicola CARLON ZAMBON

“Chirality and nonlinear dynamics in polariton microresonators”

Jury members :

Natalia G. Berloff, Professeure, Cambridge University, Rapporteure
Ivan Favero, Directeur de Recherche, CNRS - Université de Paris, Rapporteur.
Jean-Jacques Greffer, Professeur, Institut d'Optique, Examinateur.
Ataç Imamoğlu, Professeur, ETH Zürich, Examinateur. A
Alessandro Tredicucci, Professeur, Università di Pisa, Examinateur.
Jacqueline Bloch, Directrice de Recherche, CNRS (UMR 9001), Directrice de thèse.
Alberto Amo Garcia, Chargé de recherche, Université de Lille - CNRS (UMR 8523), Invité

Abstract :

Semiconductor microresonators, defined by a planar Fabry-Perot cavity embedding a quantum well, allow tightly confining both optical and electronic excitations. In these heterostructures, light and matter interact so rapidly that the fundamental excitations of the system can be effectively described as hybrid light-matter quasiparticles, called exciton-polaritons. The excitonic component endows the system with a large Kerr-type nonlinearity, while tailoring of the photon dispersion is implemented via a dry etching processing technique. The versatility of this hybrid photonic platform allows us investigating diverse phenomena, such as the non-equilibrium dynamics of interacting bosons on a lattice, the hydrodynamics of quantum fluids and novel concepts for coherent light sources. After a general introduction and a presentation of the microcavity samples, we present two experimental works realized during the PhD.

In the first, harnessing an analogue spin-orbit coupling effect in ring-type arrays of microcavities, we propose and demonstrate a novel microlaser architecture. The microlaser emission presents a helical wavefront, i.e. carries a net orbital angular momentum. Contrary to previous works, in our scheme time-reversal symmetry is broken by optical means, enabling a fast control of the wavefront twist.

In the second work, we consider single microresonators where the nonlinearity is already significant for few dozen excitations. The interplay between coherent driving, loss and nonlinearities triggers a regime of optical metastability activated by vacuum fluctuations. With the idea of drawing a parallel with the stochastic thermodynamics of mesoscopic systems, we define and measure the entropy production at a single trajectory level, testing a non-equilibrium fluctuation dissipation theorem.

Finally, we discuss future research directions based on the engineering of spin-orbit coupling or the use of our metastable states as random classical bits.

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