Internship proposal - 2nd year master

Waveguide Polariton Lasers: quantum fluids of light for integrated photonics

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The interaction between electronic excitations (excitons) and photons is strongly enhanced in optical microcavities, compared to a bulk medium. When the interaction is large enough, it can reach the strong coupling regime, where the perturbation theory isn't suitable anymore to understand the light-matter interaction. In this regime, the new eigenstates are the so-called polaritons, half exciton/half photon quasi-particles. They can be generated, transported, accumulated in dense quantum phases and brought into strong interactions. The discovery of the Bose condensation of polaritons in 2006 [1] (at low temperature in a GaAs microcavity) has triggered many interesting research projects and led to the discovery of the superfluidity of polariton condensates, the observation of unique kinds of vortices in these "quantum fluids of light", and the development of polaritonic devices.

GaN and ZnO-based microcavities have raised a large interest in the community thanks to their robust excitons and large oscillator strength. Indeed polariton condensates can be demonstrated at room temperature, which is a striking advantage with respect to GaAs devices operated at cryogenic temperatures. Within a collaboration with the laboratories CRHEA, C2N and IP (with present fundings from ANR and the Labex Ganext), our group has demonstrated in 2013 the condensation of polaritons in a ZnO microcavity at 300K [2,3].

The present internship proposal is focused on a new kind of polaritonic device: the polaritonic waveguide, i.e. an optical waveguide in which propagating photons and excitons are in the strong coupling regime [4]. The waveguide polaritons have much longer lifetimes than cavity polaritons due to the low waveguide losses, and their investigation in GaAs is quite recent [5]. Dedicated samples from CRHEA and C2N based on ZnO and GaN show that polariton lasing can be achieved in this new geometry [5], with the formation of new polariton condensates. After our recent demonstration of polariton lasing in a GaN polariton waveguide [6], we plan to control the operation of the laser under electrical injection and to discriminate continuous versus pulsed operation regimes. This last transition is related to the non-linear formation of polariton condensates and associated solitonic phases in polaritonic waveguides, inspired from the atomic physics community, at the frontier between non-linear optics, quantum optics and condensate physics.

We are looking for a motivated student interested in optical experiments, and a possible continuation as a PhD. The applicants are expected to have a background in semiconductor physics, quantum mechanics and optics. This project is part of the ANR-funded NEWAVE program, starting in January, 2022.

References

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