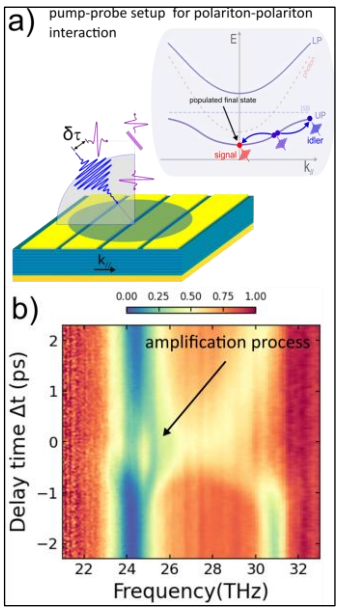
Centre DE Nanosciences & DE Nanotechnologies

M2 Internship offer 2026/2027

Departement/Team: Photonique/ODIN
Person in charge of the internship: Jean-Michel Manceau
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Passive and nonlinear characterization of novel ISB polariton architectures

Scientific project: Quantum electrodynamics (QED) is a central theme of modern photonics, aiming at tuning the radiative properties of a given transition through its coupling to the electromagnetic field. One spectacular manifestation of QED is the formation of polaritons: new hybrid light-matter states that emerge when a material transition is strongly coupled to a photonic mode, and that can be treated as interacting bosons. This bosonic character opens the door to final-state stimulation, whereby polariton-polariton scattering preferentially feeds an already macroscopically occupied state, and, ultimately, to a polariton laser — a coherent light source whose gain comes directly from a macroscopically populated polariton state, rather than from the population-inverted electronic transitions used in conventional lasers. Intersubband (ISB) polaritons, formed by coupling intersubband transitions in doped semiconductor quantum wells to a microcavity, are attractive candidates for such a device: unlike their excitonic counterparts, their transition energy can be freely tuned by varying the quantum well width and doping, giving direct access to the mid-IR and far-IR. We have recently demonstrated polariton-polariton interaction in this stimulated regime for ISB polaritons [1] (see figure), an essential step on the path to a polariton laser. One route towards this goal consists in extending the polariton lifetime; a complementary route is to look beyond the standard ISB-polariton platform, towards other inorganic architectures offering intrinsically stronger polariton-polariton interaction.



In this continuity, this internship aims at the experimental characterization of novel polaritonic architectures based on multisubband plasmons and on bound-to-continuum intersubband transitions strongly coupled to a microcavity [2,3], using samples already fabricated within the team. The candidate will first carry out the passive (linear) characterization of these samples, recording angle-resolved reflectance spectra to map the polariton dispersion and extract the strong-coupling parameters (Rabi splitting, anti-crossing, oscillator strength). Building on this characterization, the candidate will then move to the nonlinear regime, using the mid-IR pump-probe setup recently built in the team to monitor the reflectance of the samples as a function of pump fluence and pump-probe delay. The goal will be to capture, on the ultrafast timescale, the saturation of the strong coupling and the resulting renormalization of the polariton resonances (blue-/red-shift, linewidth), and to compare the two architectures on this basis.

If time allows, the candidate will also follow the fabrication process of the samples in the cleanroom, giving a global view of the team's activities, from optical design to cleanroom fabrication and optical characterization.

[1] M. Knorr et al., *Intersubband Polariton-Polariton Scattering in a Dispersive Microcavity*, Phys. Rev. Lett. **128**, 247401 (2022).
[2] A. Delteil et al., *Charge-Induced Coherence between Intersubband Plasmons in a Quantum Structure*, Phys. Rev. Lett. **109**(24), 246808 (2012).
[3] E. Cortese, N.-L. Tran, J.-M. Manceau, A. Bousseksou, I. Carusotto, G. Biasiol, R. Colombelli, and S. De Liberato, *Excitons Bound by Photon Exchange*, Nat. Phys. (2020).

Methods & techniques: Linear and nonlinear optical spectroscopy, ultrafast pump-probe technique, data processing, instrument control (Python).
Possibility to go on a PhD: Yes
Funding: Doctoral school scholarship or research grant