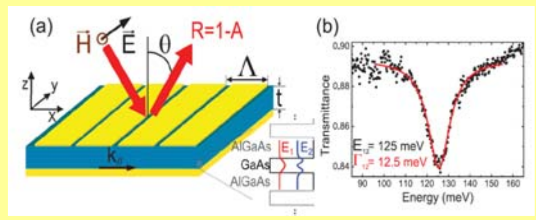
Spécialité de Master « Optique, Matière, Plasmas »

Stage de recherche (4 mois minimum, à partir de début mars)



Proposition de stage (date de la proposition : 10/2014)

Responsable du stage / *internship supervisor*:

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Code d'identification : UMR8622 Organisme : Université Paris Sud et CNRS

Site Internet / *web site*: http://pages.ief.u-psud.fr et aussi http://pages.ief.u-psud.fr/~colombel/index.htm

Adresse / *address:* Université Paris Sud, 91405 Orsay

Lieu du stage / *internship place*: **Institut d'Electronique Fondamentale - Orsay**

Titre du stage : **Polaritonic emitting devices**

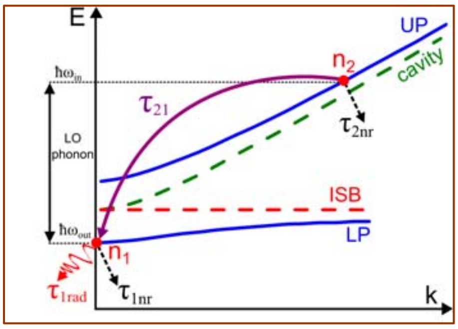
Résumé / summary

We are accustomed to optoelectronic devices operating in the weak coupling regime between light and matter. Conventional lasers, for instance, operate in this regime and rely on population inversion to achieve optical gain. Recent years have seen a surge of interest for quantum systems operating in the *strong coupling* regime instead, i.e. when the coupling strength for the light-matter interaction is so strong, that perturbation theory does not suit anymore the description of the system. The new eigenmodes are a superposition of states – partially light, partially material excitation – called cavity polaritons.

In this context, a different type of "laser" was proposed in 1996 [1], which does not rely on population inversion, but on bosonic final-state stimulation. In a bosonic system, the probability of transition towards a final state is proportional to the population of said state. Polariton lasing happens when the scattering time towards the ground state is shorter than the lifetime of the final state. Population then builds up abruptly. Polariton lasers are interesting since they are weakly dependent on operating temperature, in contrast with standard semiconductor lasers.

Recently, polaritons have been explored in a different system, where the material excitation is an intersubband (ISB) transition in a semiconductor quantum well. They are called *intersubband polaritons* [2]. ISB transitions constitute the backbone principle behind quantum cascade lasers. Their strength and design flexibility (the ISB transition energy can be tailored over a broad wavelength range by changing the layer thickness) is the key ingredient which made QC lasers effective coherent mid-IR semiconductor sources, and also promising THz sources. Transferring such flexibility into the realm of polaritons has been one of the motivations behind the development of ISB polaritonics.

The goal of this stage is ambitious: to develop polaritonic light-emitting devices based on ISB polaritons and operating in the mid-infrared spectral range, a spectral region very important for applications. The activity builds upon recent developments of the host team at IEF [3]: microcavity resonators whose energy dispersion enables polariton-polariton or polariton-phonon scattering processes - as depicted in the Figure – on which a polaritonic laser or amplifier can rely on.



The stage is both theoretical and experimental. The successful candidate will perform analytical studies and numerical simulations of the devices which will then be fabricated and tested in the laboratory.

Acquired know-how : Electromagnetic modeling ; quantum devices physics and technology ; laser physics ; Fourier transform spectroscopy ; optoelectronic characterization techniques ; quantum design.

Références :

[1] Imamoglu, A., et al., *Nonequilibrium condensates and lasers without inversion: Exciton-polariton lasers.* Phys. Rev. A **53**, 4250 (1996).

[2] Dini, D., et al., *Microcavity Polariton Splitting of Intersubband Transitions.* Physical Review Letters, 2003. **90**, p. 116401.

[3] Manceau, J.M., et al., *Mid-infrared ISB polaritons in dispersive metal-insulator-metal resonators.* Appl. Phys. Lett. **105**, 081105 (2014)

Ce stage pourra-t-il se prolonger en thèse ? *Possibility of a PhD* **? : OUI**

Si oui, financement de thèse envisagé/ *financial support for PhD*: **Bourse ministère or ANR or ERC**

Lasers, Optique, Matière	X	Lumière, Matière : Mesures Extrêmes	