Centre de Nanosciences et de Nanotechnologies

Habilitation à diriger des recherches

Jeudi 21 septembre

14 heures

Salle Richard Planel du C2N site Marcoussis

Alejandro Giacomotti

" Non-linear dynamics in active photonic crystals"

Membres du jury

Prof. Guy Millot , Laboratoire Interdisciplinaire Carnot de Bourgogne (ICB) UMR 6303, CNRS Université de Bourgogne

Prof. Jesper Mork, DTU FOTONIK, Department of Photonics Engineering, Technical University Denmark

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Prof. Philippe Lalanne, Laboratoire de Photonique, Numérique et Nanosciences UMR 5298-LP2N, Institut d'Optique d'Acquitaine

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Résumé:

This HDR focuses on fundamental aspects of the nonlinear interaction between light and matter in active –III-V semiconductor– photonic crystals. The combination of large nonlinear optical susceptibilities with high quality factors and small optical mode volumes of micro/nano optical resonators leads to a wealth of complex physical phenomena, even at a single cavity level: optical bistability, neuron-like spiking in the form of optical excitability, self pulsing dynamics... Their observation in novel micro and nano resonators has been a challenge over the past fifteen years. My work after my PhD thesis, carried out at LPN (now C2N) from 2004, has been devoted to this quest.

Beyond the single cavity limit, photonic crystal platforms offer new opportunities to study light matter interaction in arrays of coupled cavities. The interplay between photon tunneling and nonlinearity in multi-well optical potentials –or photonic molecules– is at the heart of many recent developments in quantum and nonlinear optics. As a central part of this HDR report I will focus on a key phenomenon taking place in double well potentials: the spontaneous mirror-symmetry breaking, which we have demonstrated for the first time at the nanoscale using two coupled nanolasers. The system undergoes a bifurcation from delocalized to localized states in the wells, which are mirror images of each other. I will show that, in order to achieve this goal, a thorough optimization of the coupled cavity system is needed in terms of both photon collection and, more importantly, the control of inter-cavity coupling. For the latter we have proposed an original photonic crystal barrier engineering design that enables not only a large tuning of the coupling strength, but also the control over its sign.

Unexpectedly, we found that the photon number at the bifurcation is about ~ 150, which could even be further reduced by increasing the spontaneous β-factor of the nanolasers. We can thus predict such transitions with few intracavity photons in future nanolaser devices. Ultimately, signatures of quantum correlations could also be expected in future nonlinear coupled nanocavity devices close to symmetry breaking transitions.