Soutenance de thèse

Vendredi 31 Mai

14h, Amphithéâtre - C2N

Time gating four wave mixing to measure the dynamics of semiconductor nanolasers

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Jury Members :

Abstract :

PhC nanolasers are receiving increasing attention due to their unique capacity to manipulate and confine light at a very small scale. Their small footprint and low thresholds make them ideal candidates for realizing optical interconnects, thus addressing the increasing demands for data transmission speed and power consumption. Moreover, their singular geometry enables the control of their spontaneous emission properties. This reveals the unique nature of PhC nanolasers from a fundamental perspective, highlighting their potential to serve as candidates for novel research in light-matter interaction. Despite these advantages, the current limitations in near-infrared detection capabilities impede the comprehensive characterization of their emission and dynamical properties, leaving a crucial gap in our understanding of these devices.

This thesis presents a time-gating detection technique based on four wave mixing, developed to measure the ultra-fast response of 1D nanolasers. By studying the interplay between nonlinearities and dispersion, a high sensitivity level of a few photons and a resolution of 2 picoseconds has been achieved. Further improvements in sensitivity, down to detection of less than one photon, are predicted by employing higher gate powers. This approach can be applied to the study of photon statistics and the quantum nature of materials.

The profiles of 1D nanolasers exhibit a rapid onset of emission and long decay, consistent with a β factor of 0.12 and a photon lifetime of 20 picoseconds.

A novel approach to obtaining the values of these two parameters controlling laser dynamics has been developed: they have been directly retrieved from the ultra-fast response of nanolasers, instead of solely relying on steady-state measurements such as the S curve, which, in many cases, can lead to inaccurate estimations due to the interdependence of these parameters. The dynamical response of 1D nanolasers is compatible with a maximum modulation speed of approximately 30 GHz, which fulfills the requirement for low-threshold ultracompact laser sources for photonic integrated circuits and optical communications.

The high sensitivity and resolution of the technique permitted the first measurement of an adiabatic wavelength conversion of photons with a wavelength shift as large as 1.2 nanometers. This demonstrates the potential of the technique in studying ultra-fast dynamics at near-infrared wavelengths.