MASTER IN PHOTONICS – "PHOTONICS BCN" ERASMUS+ "EUROPHOTONICS-POESII"

MASTER THESIS PROPOSAL

Dates: April - September 2018

Laboratory: DONLL, Nonlinear Dynamics, Nonlinear Optics and Lasers
Institution: Universitat Politècnica de Catalunya
City, Country: Terrassa, Catalunya

Title of the master thesis: Direct fiber-coupling of VCSELs through a radial PT-Symmetric pump.

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Keywords: Semiconductor Lasers, PT-symmetry, Non-Hermiticity

Summary of the subject (maximum 1 page):

Semiconductor Lasers are compact sources of coherent light used for many purposes. In particular Vertical-Cavity Surface-Emitting Lasers (VCSELs) are especially advantageous for their high light conversion efficiency, and low lasing threshold. VCSELs usually present dynamical spatiotemporal chaotic behaviors arising from modulation instability and resulting in a poor spatial beam quality. Moreover, the lack of an intrinsic transverse mode selection mechanism develops a deep multimode operation and for high enough pumping rates self-focusing, filamentation and spatial hole burning appear restricting the possible applications [1]. Some recent considered methodologies directly act on the arising Modulation Instability to stabilize VCSELs [2].

Usually considered stabilization methods are based on optical feedbacks acting in the temporal domain or in the reduction of transverse modes like Vertical External Cavity Surface Emitting Lasers (VECSELs) that usually limits the size of the active region and the possible output power and also reduce robustness, compactness and applicability [3]. All these efforts are directed to enhance focalization and maximize the power that can be coupled into a fiber. This is of extreme importance to guide the laser power and improve in this way the applicability of these lasers.

Our proposal is a VCSEL device with an output fiber piercing the laser and directly collecting the generated laser power from the whole laser cavity. The laser light generated in the entire transverse area of the VCSEL is concentrated by an axial modulation of refractive index and gain in a Parity-Time symmetry.

The spatial modulation of the complex refractive index, i.e. refractive index in the real part and gain-loss in the imaginary part, has demonstrated strong capabilities to tailor light dispersion, including diffraction and diffusion and showing different spatial effects in linear light propagation [4,5,6]. Further, the same modulations in nonlinear systems introduce the management of spatial instabilities that intrinsically appear in laser systems and amplifiers [7].

The field is localized in a narrow beam at axis where the output fiber is located (see Fig.1).
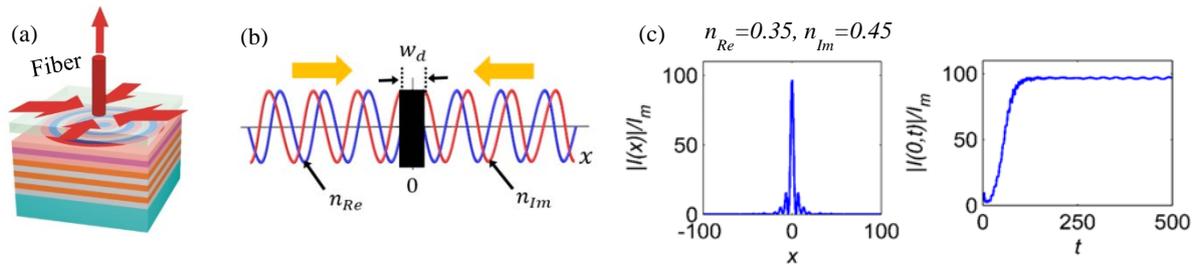

Fig.1. (a) Schematic of a VCSEL laser with PT-symmetric geometry and pierced output fiber. (b) PT-symmetric modulation of the refractive index amplitude (n_{Re}) and gain (n_{Im}). (c) Preliminary simulation with an output intensity 100 times larger than the saturated laser intensity. Spatial field distribution and temporal evolution.

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Additional information:
* Required skills: Basic programming experience in Mathematica, Matlab, Fortran or C++
* Miscellaneous: