



## **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:** PT-Symmetric arrays of Broad Area Semiconductor Lasers

**Name of the master thesis supervisor:**

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

**Summary of the subject (maximum 1 page):**

Controlling the flow of electromagnetic fields has been the subject of an intensive research over the time. In recent years, transformation optics [1], flat optics [2], and finally non-Hermitian optics [3] have become fertile playgrounds enabling a direct control over the propagation of light. Non-Hermitian optics has recently attracted a significant attention deriving from the parity and time symmetry breaking in complex optical systems, referred as PT-symmetric systems. Those systems may eventually hold a nontrivial effect: the unidirectional flow of light. This new concept provides a powerful mechanism to dynamically shape probe fields, and such precise control may have potential novel implications in actual physical systems.

In the DONLL research group we have theoretically contributed to this field deepening in the analysis of such two-dimensional (2D) systems. We demonstrated asymmetric chiral flow in

2D PT-symmetric systems, and shown non-diffractive propagation in complex and 2D PT-symmetric systems [4]. More recently, we have explored local PT-symmetry and proposed direct applications into the actual laser technology [5] and further generalized to arbitrary vectorial fields [6].

The proposed project goes precisely in this last direction of implementing this new concept into actual Broad Area Semiconductor (BAS)-laser arrays. The project is aimed at improving the brightness of these BAS-laser arrays by implementing a PT-axisymmetric geometry in their coupling to shape and stabilize the output beam, as schematically shown in Fig. 1a. Preliminary numerical results with a simple paraxial model already lead to promising results for the case of a Broad Area Semiconductor lasers, see Fig. 1b.

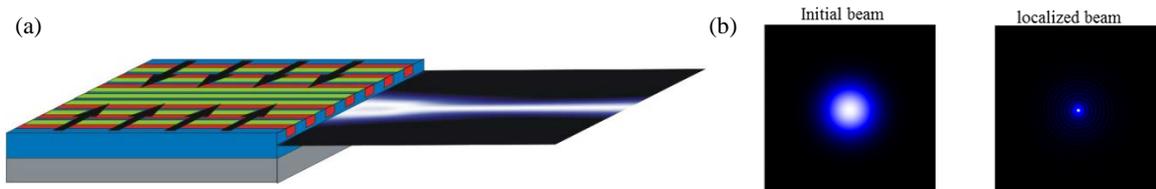


Fig.1. (a) Schematic of a BAS-laser array with a PT-axisymmetric geometry with a bright and narrow output beam. (b) Preliminary paraxial simulation for a PT-symmetric BAS amplifier showing the concentration and enhancement of the field on axis.

This study is related with the NATO Science for Peace project SPS 985048 and the European project HIP-Lasers, where several photonic companies from Germany, Lithuania and Catalonia. The candidate thus can collaborate with industry units and has a chance to extend his post-master academic career there, or in our UPC group.

- [1] J. B. Pendry et al., "Controlling electromagnetic fields," *Science* 312, 1780–1782 (2006).
- [2] A. Guo et al., "Observation of PT-symmetry breaking in complex optical potentials," *Phys. Rev. Lett.* 103, 093902 (2009).
- [3] N. Yu and F. Capasso, "Flat optics with designer metasurfaces," *Nat. Mater.* 13, 139–150 (2014).
- [4] M. Turduev, M. Botey, I. Giden, R. Herrero, H. Kurt, E. Ozbay, and K. Staliunas. "Two-dimensional complex parity-time-symmetric photonic structures." *Phy. Rev. A* 023825 (2015). R. Herrero, M. Botey, and K. Staliunas, *Phy. Rev. A* 063811 (2014). W.W. Ahmed, R. Herrero, M. Botey, K. Staliunas, *Phys. Revi. A* 053830 (2017)
- [5] W. W. Ahmed, R. Herrero, M. Botey, K. Staliunas, "Locally parity-time-symmetric and globally parity-symmetric systems" *Phys. Rev. A*053819 (2016).
- [6] W.W. Ahmed et al., "Directionality Fields generated by a Local Hilbert Transform," under review in *Phys. Rev. Lett.* (2017) (arxiv: 1707.04556).

**Additional information:**

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