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# MASTER IN PHOTONICS – “PHOTONICS BCN” Master ERASMUS+ “EUROPHOTONICS”

## MASTER THESIS PROPOSAL

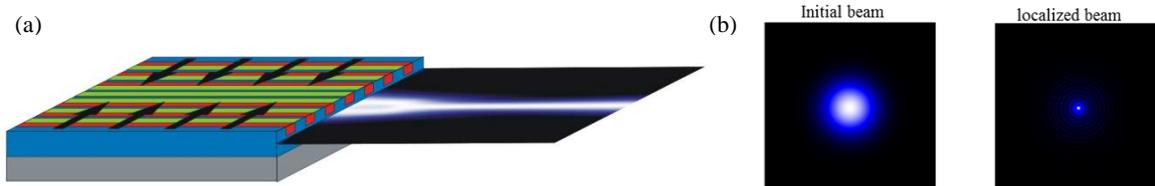
**Dates: April - September 2021**

**Laboratory:** DONLL group , Nonlinear Dynamics, Nonlinear Optics and Lasers

**Institution:** Universitat Politècnica de Catalunya

**City, Country:** Terrassa, Catalunya

**Title of the master thesis:** PT-Symmetric arrays of Edge Emitting Lasers



(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.

**Name of the master thesis supervisor and co-supervisor:** Ramon Herrero, Muriel Botey, Kestutis Staliunas

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**Keywords:** Non-Hermitian optical systems, Parity-Time symmetry, metamaterials, asymmetric polarizers

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

**Summary of the subject:**

**Aim:** Asymmetric coupling between neighboring lasers in a semiconductor laser array.



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**Project.** Controlling the flow of electromagnetic fields has been the subject of an intensive research over the time. In recent years, the research of the DONLL group has been working in non-Hermitian Photonics for a smart control of light [1][2].

Non-Hermitian Photonics, in particular PT-symmetric systems [3] 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 demonstrated asymmetric flow in 2D PT-symmetric systems, and shown non-diffractive propagation in complex and 2D PT-symmetric systems. More recently, we have explored local PT-symmetry and proposed direct applications into the actual laser technology and further generalized to arbitrary vectorial fields.

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

This study is in the framework of international collaborations of the DONLL group involving several photonic companies from Germany to Lithuania and Catalonia. The candidate thus may collaborate with international partners.

[1] Ahmed, W. W., Herrero, R., Botey, M., Wu, Y., & Staliunas, K. (2020). Restricted Hilbert transform for non-Hermitian management of fields. *Physical Review Applied*, 14(4), 044010.

[2] Ahmed, W. W., Herrero, R., Botey, M., Wu, Y., & Staliunas, K. (2021). Inverse-design of non-Hermitian potentials for on-demand asymmetric reflectivity. *Optics Express*, 29(11), 17001-17010.

[3] El-Ganainy, R., Makris, K. G., Khajavikhan, M., Musslimani, Z. H., Rotter, S., & Christodoulides, D. N. (2018). Non-Hermitian physics and PT symmetry. *Nature Physics*, 14(1), 11-19.

### **Additional information:**

\* Monthly allowance possible depending on value of candidate

\* Recommended skills: Programming (C++, MatLab,..)

Self-motivated, objective-driven student.

\* Miscellaneous :

International environment with collaborations with foreign universities

Possibility of joining the DONLL group for a PhD

Early incorporation welcome.

\*Expected outcome: One scientific publication