



Master in Photonics – “PHOTONICS BCN” Master ERASMUS Mundus “EuroPhotonics”

MASTER THESIS PROPOSAL

Starting full time from April 2025

Presentation at the end of July or beginning of September 2025

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

Institution: Universitat Politècnica de Catalunya

City, Country: Terrassa, Catalunya

Title of the master thesis: Non-Hermitian structured optical fibers and waveguides

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Keywords: Optical fibers. Waveguides. Non-Hermitian potentials. Mode management. Self-cleaning.

Summary of the subject (maximum 1 page):

Multimode Fibers (MMF) generally show random (speckle) output, even when high spatial quality beams are injected due to the different propagation constants of the different fiber modes that dephase the modes in propagation along the fiber. Such randomization occurs even for Graded Index (GRIN) Multimode Fibers with parabolic index profiles for which the mode propagation constants are equidistant, and in principle the dephasing should not occur (periodic self-imaging is expected instead), yet the smallest imperfections along the fiber (e.g., bending, or stretching), break the mode equidistance, and the random structure of the field at the output is generally observed.

We plan to study fibers modulated in the propagation direction by a non-Hermitian potential (modulation of the refractive index and gain/loss) with different transverse refractive index profiles, starting from the parabolic profile with constant frequency difference between modes and following with more involved potentials (square, triangular) [1].

The study would start with 1D waveguides with a lower number of modes and possible potentials and extended to 2D waveguides and parabolic GRIN MMF.

The potential allows to manage the coupling between modes and we expect to control the energy distribution among modes (Fig.1). Experimental realizations are planned in collaboration with the Université de Lille (France), Aston University (England) or eventually in NKT Photonics.

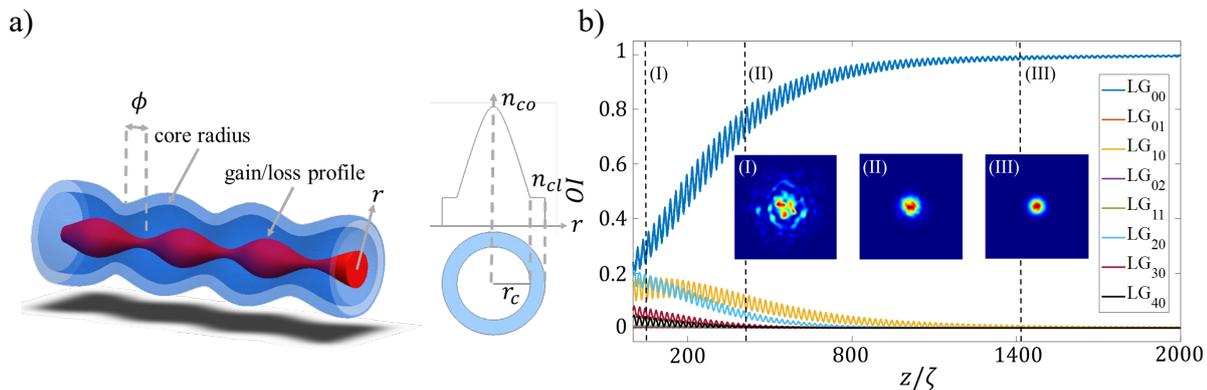


Figure a) Modulated GRIN MMF b) Evolution of the mode participation along the modulated GRIN MMF, the insets show the mode-cleaning of the transverse noisy profile

A different but even more interesting configuration is the generation of asymmetric couplings from spacetime potentials, i.e., the combination of spatial and temporal periodic modulations in the waveguide. Asymmetric and nonreciprocal couplings between modes as well as the arousal of temporal dynamics to generate pulsed emission are expected.

[1] Akhter, Mohammad Nayeem, et al. "Non-Hermitian mode management in periodically modulated waveguide amplifiers." *APL photonics* 9.10 (2024)

Additional information (if needed):

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

* Miscellaneous: This study is in the framework of a Project "Exploring complex spacetime systems for light control" (PID2022-138321NB-C21) inside the coordinated project "Exploring complex spacetime systems for unconventional light and sound wave control". Possibility of joining the DONLL group for a PhD.