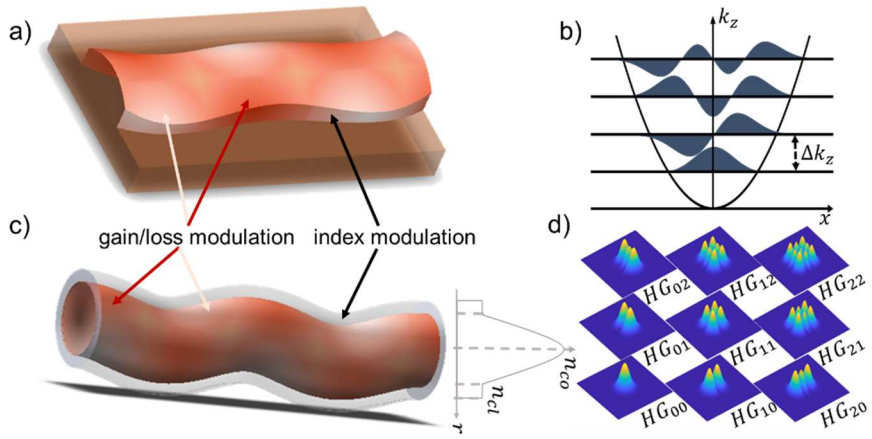
Master in Photonics – "PHOTONICS BCN"
Master ERASMUS Mundus "EuroPhotonics"

MASTER THESIS PROPOSAL

Dates: December 2023 – June 2024

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

Title of the master thesis: Non-Hermitian all-optical mode-cleaning in fibers



a)/b) Periodically modulated non-Hermitian 1D/2D waveguide. b) Lowest order Hermite modes of the 1D (unmodulated) parabolic waveguide. c) Periodically modulated non-Hermitian 2D waveguide or optical fiber, with index and gain/loss modulation along the waveguide. d) Lowest order Hermite–Gauss modes of the 2D (unmodulated) parabolic waveguide.

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

Summary of the subject:

Aim: Monitoring and exploring the experimental demonstration of all-optical mode cleaning in non-Hermitian fibers.

Project: The advent of non-Hermitian Photonics, combining both, refractive index and the gain-loss profiles, represents a new platform for a smart control of light [1].

At the DONLL group we have explored novel non-Hermitian systems for the asymmetric control of the flow of light [2] or the control of the mode dynamics in unstable optical systems, controlling turbulence [3].

Recently, we showed how periodic potentials in the transverse and longitudinal spatial directions may strongly affect the field dynamics in optical fibers [4]. The simultaneous modulation of the refractive index and the gain/loss along multimodal fibers and waveguides induces a unidirectional coupling among the modes resulting in an all-optical spatial mode cleaning. Depending on the spatial delay between real and imaginary part of the potential modulation, the higher or lower order modes are favored, eventually leading to mode-cleaning. The effect has been proven in graded index multimode optical fibers and is now being extended and improved for modulated waveguides. Indeed, an antisymmetric non-Hermitian modulation results in and effective mode-cleaning for any arbitrary initial field distribution. The effect can be easily modelled in 1D fibers or waveguides while it is more involved case of 2D systems. For 1D waveguides a noisy, highly multimodal input beam gradually evolves towards a bell-shaped transverse profile output. For 2D systems different transverse modulations can be considered.

The proposal is now being experimentally investigated with an international team involving Vilnius University and Inphotec company. The master thesis will consist on monitoring the experiments and providing the necessary calculations, and eventually designing new schemes, for further experimental demonstrations.

References

[1] El-Ganainy, R., Khajavikhan, M., Christodoulides, D. N., & Ozdemir, S. K. (2019). The dawn of non-Hermitian optics. Communications Physics, 2(1), 37.
[2] 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.
[3] Ivars, S. B., Botey, M., Herrero, R., & Staliunas, K. (2022). Optical turbulence control by non-Hermitian potentials. Physical Review A, 105(3), 033510.
[4] Akhter, M. N., Ivars, S. B., Botey, M., Herrero, R., & Staliunas, K. (2023). Non-Hermitian Mode Cleaning in Periodically Modulated Multimode Fibers. Physical Review Letters, 131(4), 043604.

Additional information:

* Allowance only for candidates enrolling before the end of 2023.
* Workplace flexibility (in the working hours and dates).
* Recommended skills: Programming (C++, MatLab,..), self-motivated student.
* Miscellaneous: International environment with collaborations with foreign universities
* Possibility of joining the DONLL group for a PhD
* Expected outcome: one scientific publication