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 2026

Laboratory: Nonlinear Optics and Lasers Lab
Institution: Universitat Politècnica de Catalunya
City, Country: Terrassa (Barcelona), Spain

Title of the master thesis: Nonlinear optics in nanostructures
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Keywords: photonic structures, nano-photonics, linear and nonlinear light-matter interaction

Summary of the subject (maximum 1 page):

Optical properties of photonic crystals have emerged as being pivotal for the study of light - matter interaction enhancement, leading to pioneer applications in nanophotonics, all-optical devices and photonic chips. Artificial periodic photonic structures in one, two and three-dimensions can alter and sometimes create new effective dispersion relations compared to bulk materials, allowing strong control over light propagation and consequently over light–matter interactions. Moreover, when combined with different types of absorptive (or emissive such as quantum dots) materials placed at the surface or at particular positions inside the structure, new scenarios may be exploited. In particular, the enhancement of the electromagnetic field obtained due to its localization either at the surface or inside the nanostructure is very important for applications in optical sensing or light emission including the UV range. To advance in these directions is very important to develop new experimental techniques to measure this enhancement in such micro and nano structures.

This project aims to conduct pioneering experimental and theoretical study of linear and nonlinear light-matter interaction in nano-structured artificial materials (photonic crystals and optical metasurfaces), in a search for new functionalities in Photonics. Some of the physical phenomena involved are the harmonic generation in opaque region of semiconductors, excitation of plasmonic waves in metals and conductive oxides and **topological surface waves.** The aim is to maximize the potential impact of nonlinear metasurfaces to new nanophotonic devices, such as multiple frequency generators, tunable emitters extended in the UV and optical sensors, all into the interconnected fields of **nanomaterials** and **nonlinear optics.**

We will investigate:
1) 1D topological photonic structures with surface-enhanced electromagnetic states. The intensity of the electromagnetic fields at these states in dramatically enhanced, which produces an enhanced linear

and nonlinear light-matter interaction. Harmonic generation and enhanced absorption on graphene will be studied.
2) Nonlinear interactions (second and third harmonic generation) in nanostructures / metamaterials made of strategic semiconductors for nanophotonics.

Objective 1: Study of the theoretical behaviour and numerical simulation of sub-wavelength modulated structures.
Objective 2: Experimental characterization of the linear properties of the photonic structures.
Objective 3: Set-up implementation and experimental measurement of the nonlinear response.

Student will be part of our active research group, being in contact with other PhD students working on different subjects in the fields of nonlinear optics, nonlinear dynamics and lasers.