









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

## MASTER THESIS PROPOSAL

## Dates: April 2023 – July or September 2023

Laboratory: Quantum and Atoms Optics group Institution: Universitat Autònoma de Barcelona City, Country: Bellaterra, Spain

Title of the master thesis: Quantum light in topological photonic lattices

Name of the master thesis supervisor and co-supervisor: Verònica Ahufinger and David Viedma

Email address: <u>veronica.ahufinger@uab.cat</u> and <u>david.viedma@uab.cat</u> Phone number: 935868178 Mail address: Grup d'Òptica. Departament de Física. Facultat de Ciències. Edifici C. Campus Universitat Autònoma de Barcelona, E-0193 Bellaterra

Keywords: optical waveguides, topology, quantum states of light

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

Due to their general robustness against defects and disorder, topological states have gathered widespread attention in several fields. For optical devices, harnessing the unique properties of these states could lead to a variety of applications, such as unidirectional propagation, lossless information transfer and general immunity to imperfections during fabrication. Most of the works involving topological photonics until now have only considered the classical description of light fields. However, recently, quantum topological photonics has been presented as a potential solution for decoherence-free transport of quantum information [1]. In this work, we propose to study the role of topology in the propagation of quantum light in photonic lattices. In particular, we will consider a system of coupled optical waveguides simulating geometries of different non-trivial topological models. The starting point will be to consider the Su-Schrieffer-Heeger (SSH) model [2], which is characterized by two intertwined one-dimensional sublattices with staggered weak and strong couplings, and address the propagation of quantum states of light (see [3] for the case of squeezed states) and their robustness against disorder. We also plan to study the diamond chain, which has been shown to exhibit Aharonov-Bohm caging [4], and use it to explore the localization of quantum states of light in a flat band (see [5] for the case of Fock states).











- [1] A. Blanco-Redondo, Proceedings of the IEEE 108, 837 (2020).
- [2] W. P. Su, J. R. Schrieffer, and A. J. Heeger, Phys. Rev. Lett. 42, 1698 (1979).
- [3] J. Medina Dueñas et al., Quantum 5, 526 (2021).
- [4] C. Jörg et al., Light Sci Appl 9, 150 (2020).
- [5] S. Rojas-Rojas et al., Physical Review A 96, 043803 (2017).

#### **Objectives:**

The general goal of this MsC Thesis is to understand the role of topology in the propagation of quantum states of light. This will be achieved by fulfilling the following specific objectives:

-Study the propagation of classical and quantum light in coupled waveguides.

-Derive the topological properties of the SSH model.

-Calculate the propagation of quantum states of light and its robustness against disorder in the SSH chain.

-Derive the topological properties of the diamond chain.

-Study the localization of quantum states of light in flat bands and its robustness against disorder in a diamond chain.

#### Additional information (if needed):

\* Required background: classical light propagation in optical waveguides, quantum states of the electromagnetic field.

\* Required skills: Programming and analytical skills