MASTER THESIS PROPOSAL

Full time from April 2026 (it can start part time from February 2026)
Presentation date to be chosen: end of July or beginning of September 2026

Note: The main Master Thesis supervisor has to be a professor of the Master in Photonics program. One co-supervisor (internal or external) can be defined. Main Supervisor is responsible for the subject of the proposal and has to give continuous support to the student (research development, Report writing and presentation preparation). For external proposals a co-supervisor from the Master program and a collaboration agreement with UPC are needed.
You can find all information about the Master Thesis process in our webpage.

Laboratory: Optoelectronics group (led by Prof. Dr. Valerio Pruneri)
Institution: ICFO - The Institute of Photonic Sciences
City, Country: Castelldefels (Barcelona), Spain

Title of the master thesis: On-chip entangled photon source for robust and miniaturizable quantum communication transmitter

Name and affiliation of the master thesis supervisor: Prof. Dr. Valerio Pruneri (supervisor), ICFO
Name and affiliation of the co-supervisor (if any): Dr. Robin Camphausen, Dr. Stefano Signorini (for external proposals a co-supervisor chose among the Master Program professors and a collaboration agreement with UPC is needed)
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Keywords: Quantum communication, photonic integrated circuits, entanglement, quantum optics, nonlinear optics

1. **Summary of the subject:**

   Entanglement is a fundamental resource in many quantum communication and information processing protocols. For example, in the field of quantum-safe communication, it is known that unconditionally provably secure communication (what is known as device-independent quantum key distribution) can only be achieved through the use of entanglement. In quantum technologies it is therefore a critical building block to implement high-performance, efficient entangled photon sources (EPSs). Moreover, while bulk optics and fibre optics based EPSs are already relatively mature, it would be desirable to implement EPSs also on-chip. This

would drastically reduce device size, weight, and power consumption, as well as making EPSs a truly scalable mass-manufacturable technology.

This project will focus on the experimental demonstration of entanglement generation in photonic integrated circuits (PICs), i.e. photonic chips. The student will construct an experimental lab setup to characterize classical and quantum optical properties of photonic chips, investigating also the nonlinear optical process at the basis of the entangled photon generation. The experimental work will also cover the certification of the generated entanglement from the chip. Special focus will be on the application for quantum-safe communication across free-space optical links, such as are envisioned for a future satellite-based quantum communication network.

This project combines quantum optics lab research with technology development towards real-world applications, and may lead to novel intellectual property and/or scientific journal publication.

2. References:

[1] Miloshevsky, A., Cohen, L. M., Myilswamy, K. V., Alshowkan, M., Fatema, S., Lu, H. H., ... & Lukens, J. M. (2024). CMOS photonic integrated source of broadband polarization-entangled photons. *Optica Quantum*, *2*(4), 254-259.

3. Objectives:
- Constructing PIC probe station experimental setup
- Optical characterization of PICs
- Measurement of quantum optical properties of on-chip generated light
- Certification of entanglement and its application for quantum communication

Additional information (if needed):
Required skills:
- Familiarity with programming using Python programming language (common scientific computing libraries such as NumPy etc) or Matlab or similar
- Previous experience with optics laboratory setups would be a bonus
- Familiarity with experimental quantum information tools (entanglement, tomography, common QKD protocols) would be a bonus