



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: Optoelectronics group (<https://www.icfo.eu/research-group/15/optoelectronics/home/>)

Institution: ICFO - The Institute of Photonic Sciences

City, Country: Castelldefels (Barcelona), Spain

Title of the master thesis: Synchronization of SPAD-cameras: hardware for high-dimensional quantum technologies

Name of the master thesis supervisor and co-supervisor: Prof. Dr. Valerio Pruneri (supervisor), and Dr. Jorge Fuenzalida, Dr. Robin Camphausen (co-supervisors)

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Keywords: Quantum entanglement, spatial correlations, SPAD camera

Summary of the subject (maximum 1 page):

Quantum technologies, a frontier of innovation, have the potential to transcend classical limits in applications across communication and information processing. These technologies, primarily powered by quantum entanglement, face a significant challenge in increasing the dimensionality of systems, a demanding task in quantum physics. Moreover, there is a lack of quantum hardware such as detectors for carry on measurement of high-dimensional quantum states.

The project consists of the synchronization between two single-photon avalanche diode (SPAD) cameras. This technique will become pivotal for quantum technologies since will allow the measurement of correlations between two optical fields in a multi-mode scenario. The project considers measuring spatial entanglement using these cameras.

The student will form part of the Optoelectronics group at ICFO, led by Prof. Valerio Pruneri, working closely with members of the quantum imaging team in order to take advantage of the group's expertise in quantum optics.

References:

[1] Baptiste Courme, Chloé Vernière, Peter Svihira, Sylvain Gigan, Andrei Nomerotski, and Hugo Defienne, "Quantifying high-dimensional spatial entanglement with a single-photon-sensitive time-stamping camera," *Opt. Lett.* 48, 3439-3442 (2023).

[2] Bruno Eckmann, Bänz Bessire, Manuel Unternährer, Leonardo Gasparini, Matteo Perenzoni, and André Stefanov, "Characterization of space-momentum entangled photons with a time resolving CMOS SPAD array," *Opt. Express* 28, 31553-31571 (2020).



Objectives:

- 1) Understanding of quantum optics experiments, including quantum spatial correlations
- 2) Manipulation of SPAD cameras

Additional information (if needed):

* Required skills:

- Familiarity with programming using Python programming language (common scientific computing libraries such as NumPy, etc)
- Motivation to work and passion for quantum physics
- Previous experience with optics laboratory setups would be a bonus

* Miscellaneous:

Stipend: yes, for details please enquire when applying