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

MASTER THESIS PROPOSAL

Starting full time from April 2024
Presentation at the end of July or beginning of September 2024

Laboratory: Quantum Photonics
Institution: ICFO
City, Country: Castelldefels, Spain

Title of the master thesis: Light-matter entanglement for hybrid quantum networks

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Keywords: Quantum memory, entanglement, quantum networks

Summary of the subject (maximum 1 page):

This master's thesis proposal is in the framework of a project aiming at demonstrating hybrid quantum networks, focusing on the generation of hybrid entanglement between two disparate quantum nodes, a cold atomic ensemble (rubidium) and a rare-earth ion doped crystal. The student will primarily focus on the atomic side of the experiment, working towards generating light-matter entanglement through the application of the DLCZ protocol and subsequent quantum frequency conversion techniques.

Quantum networks allowing entanglement distribution between remote quantum nodes offer new capabilities for secure communication and quantum information processing. To build such a network, various kind of nodes with different capabilities will be needed. By establishing entanglement between distant and heterogeneous quantum systems, such as a cold atomic ensemble and a rare-earth ion crystal, we aim to demonstrate a building block of the envisioned hybrid quantum network.

The proposed project centers around the cold atom setup, employing the well-known DLCZ (Duan-Lukin-Cirac-Zoller) protocol to generate entanglement between a single-photon and an atomic collective excitation. Specifically, a 780nm entangled photon will be generated, and subsequent quantum frequency conversion techniques will be employed to convert it to telecom wavelength. This conversion ensures compatibility with the photons generated in the rare-earth ion crystal experiment, enabling the crucial Bell-state measurement required for remote entanglement generation.

The successful completion of this project necessitates a multidisciplinary approach, involving the fields of atomic physics, atomic trapping, quantum information, quantum communication, and entanglement. The student will primarily focus on the cold atom side of the experiment, working closely with a post-doctoral researcher who will provide guidance and collaborate on various aspects of the project.

Objectives:

- Operate a quantum memory based on cold Rb atomic ensembles
- Generate measure and characterize entanglement between a photon at 780 nm and a collective atomic excitation
- Convert the entangled photon to 1550 nm using difference frequency generation in a non-linear waveguide