



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: Fiber-integrated on-demand solid-state quantum memory for quantum networks

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Keywords: Solid-state quantum memory, laser written waveguides, quantum networks

Summary of the subject (maximum 1 page):

Context: The realization of quantum networks is a long-standing goal of the field of quantum technologies with applications ranging from secure communications to distributed quantum computing, simulation and sensing. However, at long distance, losses ultimately limit the achievable rate of distribution of entanglement between nodes. This limitation can be overcome in a quantum repeater architecture featuring sources of entangled photons and on-demand quantum memories.

General aim of the project: This master project aims at the demonstration of storage and on-demand retrieval of single photons in a fully-integrated fiber-pigtailed quantum memory. While previous realizations of quantum repeater architectures rely on bulk, free-space optical quantum memory with limited scalability, our approach benefits from reduced footprint as well as better long-term stability. In addition we aim at going beyond the state-of-the-art by demonstrating on-demand storage, a feature that was lacking in the previous results of the group with fiber-pigtailed QMs [1].

Experimental platform: The student will work with solid-state quantum memories made of ensembles of Pr³⁺ rare-earth ions doped into a YSO crystal. Light storage is done using the atomic frequency comb protocol (AFC). This system has been proven to be suitable for quantum networks since it supports high efficiency, long-lived, as well as time and frequency-multiplexed single-photon storage. Rare-earth doped crystals are compatible with on-chip integration as waveguides can be drawn within the crystal matrix through femtosecond laser writing and fiber-pigtailed allowing for tight light confinement and guiding, with increased light-matter interaction. This research activity at



QPSA group is benefiting from a long-standing collaboration with the group of Dr. Roberto Osellame at Istituto di Fotonica e Nanotecnologie (IFN) in Milan (Italy) who will fabricate the waveguides and carry out the fiber-pigtailing process.

Objectives:

- To characterize new generations of waveguides with the aim of increasing storage performance (lower spin inhomogeneous broadening, higher AFC optical depth)
- To demonstrate low noise on-demand storage of weak coherent pulses at the single photon level in the $\text{Pr}^{3+}:\text{YSO}$ spin ground state
- To realize on-demand storage of single photons from a non-degenerate cavity-enhanced SPDC entangled-photon-pair source

[1] Rakonjac, J. V. et al. Science Advances 8, eabn3919 (2022)