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: Two-dimensional arrays of solid-state quantum memories

Name of the master thesis supervisor and co-supervisor: Dr Markus Teller and Prof Hugues de Riedmatten
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Keywords: Solid-state quantum memory, entanglement, quantum networks

Summary of the subject (maximum 1 page):

In intercity quantum networks, entanglement between distant quantum network nodes is established in a heralded fashion: a classical signal that travels to the network nodes heralds the success of an entanglement attempt. The travel time or communication time, however, limits the entanglement rate for intercity quantum networks, as after each entanglement attempt, the nodes have to wait for the arrival of the heralding signal. This challenge can be tackled by means of multiplexing: entanglement attempts are performed in different degrees of freedom without the need to wait for the communication time.

In this master's project spatial multiplexing will be explored as a route to increase the entanglement rate in a quantum network by a factor of 100. Spatial multiplexing is a technique, in which a solid-state crystal is divided into smaller cells or sub-memories, each working as a fully functional quantum memory. By means of an acousto-optical deflector, we address each quantum memory separately, which allows us to sequentially entangle each memory with a distant memory, without the need to wait for the communication time. Currently, we have a fully operational quantum network apparatus with spatially multiplexed solid-state quantum memories in one-dimension and are on the brink of entangling 11 spatial modes with telecom photons. As the entangling rate increases linearly with the number of modes or memories, we expect to measure an 11-fold improvement in the entanglement rate. At the moment, this system operates only in one dimension, however, it is extendable to two dimensions.

As part of our spatial multiplexing team, the student will be responsible for the transition to two dimensions with the goal of designing and developing a setup for 100 spatial modes, a world record

for solid-state systems. The skills to be acquired include hands-on experience in programing arbitrary waveform generators, radio-frequency electronics, design of optical setups with Zemax as well as operating a quantum memory and performing single photon measurements. The Master student will be supported by a postdoc and a PhD student, as well as other members of the group.

Objectives:

- Design and build a two-dimensional array of spatial modes using acousto-optic deflectors
- Realize a two-dimensional array of 100 solid-state quantum memories
- Characterize the memory array with bright classical light and single photons,