NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2023-2024

Quantum memory integration of rare-earth doped crystals

General Scope :

Rare-earth ions are now well-identified systems for the development of **quantum technologies**. Because of their unique 4f electronic configuration, they form well isolated systems when embedded in crystalline matrices. They have a long coherence time at low temperatures, making them highly promising **solid-state qubits**. As solids, they offer perspectives of **integration** while keeping atomic properties (narrow lines) when interacting with light (optical or RF). **Erbium** is particularly appealing in this prospect because its optical transition falls in the telecom range and can naturally be used as a support for optical **quantum memories** and more generally as a fast and versatile element of control on the qubit.

Research topic and facilities available:

The main objective is to integrate erbium-doped materials into a photonic platform and perform a demonstration of quantum storage using this device. Most of the realizations have so far involved bulk crystals, namely oxide compounds containing yttrium. As compared to glass, silicon, or lithium niobate, rare-earth activated samples are not commercially available as a photonic platform. Based on a recognized national consortium (see below), we first propose to fabricate elementary wafers supporting rare-earth doped crystals. After a secondary integration/fabrication step to produce a waveguide, we will benefit from the light confinement to enhance the interaction. We therefore propose to perform a quantum memory demonstration using this unique device.

The internship will focus on the first steps of the project, combining fabrication processes (polishing and surface adhesion), mechanical characterization of the samples at cryogenic temperatures, and elementary spectroscopy of the ions embedded in the structure to evaluate the local strain. To follow-up, a PhD funding is available for a motivated candidate.

Possible collaboration and networking :

- Institut de Microélectronique Electromagnétisme et Photonique et le LAboratoire d'Hyperfréquences et de Caractérisation (IMEP-LAHC)
- Institut de Physique de Nice
- Institut de Recherche de Chimie Paris
- Laboratoire Kastler Brossel

Possible extension as a PhD : Yes – Grant already available

Required skills:

Experimental skills in one the domains are highly recommended : optics, laser, atomic spectroscopy.

General interest in the optimization of fabrication processes would be appreciated.

Education background in quantum physics and general optics, non-linear optics or light-matter interaction is demanded.

Starting date : First semester 2024

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