NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2021-2022

Erbium doped opto-RF platform for quantum transduction

General Scope :

Rare-earth ions because of their unique 4f electronic configuration form well isolated systems when embedded in solids. They have long coherence time at low temperature making them highly promising qubits for the development of quantum technologies: 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. Rare-earth spins also exhibit long coherence times and can be driven efficiently using RF fields. This remarkable combination of optical and spin properties make them ideal for the development of **RF-optical transducers**, and for pushing the performance of optoelectronic devices at the **quantum level**.

Research topic and facilities available :

At Institut Néel, we focus on RF to optical transduction based on a good knowledge of the spin and optical transitions of erbium doped samples which are compatible with the fibered telecom range. Appropriate compound and experimental working conditions (spin and optical transitions of interest, magnetic field orientation, temperature …) still need to be investigated to provide an efficient opto-RF converter. The physical design of the resonator with a prime focus on the RF interaction enhancement is currently under development and will be tested first at moderate **cryogenic temperature (1.5-2K)** to validate the approach before going to ultralow temperature (10-20mK).

During the internship, we propose to focus on an **erbium doped crystal of $CaWO_4$**. Remarkably narrow transitions have been observed for an unexpected orientation of the magnetic field in a symmetry plane of $CaWO_4$. A better understanding of the phenomenon requires advanced **coherent spectroscopy measurements** (optical, RF and a combination of both) and a dedicated decoherence modeling. This **experimental** study will be the basis of an **optimized opto-RF coupling configuration** using this very specific orientation.

Possible collaboration and networking :

- Institut de Recherche de Chimie Paris
- Service de physique de l'état condensé (CEA-Saclay)

Possible extension as a PhD : Yes

Required skills:

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

Education background in quantum physics and general optics, non-linear optics or light-matter interaction in the optical or RF domain (Electron Paramagnetic Resonance or Nuclear Magnetic Resonance) is demanded.

Starting date : Spring-Summer 2022

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