PhD Proposal

at the Institut de Physique de Nice
CNRS & Université Côte d'Azur

Solid-state quantum memories for quantum communication protocols

Experimental work

Context.— Rare-earth ion-doped crystals constitute a unique platform to implement a wide variety of protocols for storage and manipulation of photonic quantum information. This is notably due to their record coherence properties and the scalability they offer. Storage time of the order of one hour could be demonstrated with 'non-Kramers' ions, with a protocol opening the way to frequency multiplexed storage: the atomic frequency comb. This protocol is based on the shaping of a periodic absorption pattern on the ensemble, allowing for the rephasing of the excitation after a pre-determined delay. Up to now, simple and regular spectral pattern could be shaped on the ensembles, forcing the re-emission of all the spectral components synchronously, in the forward direction. This ultimately limits the maximum achievable storage efficiency as well as the spectral analysis ability of the ensemble.

Objectives.— The objective of this thesis is to explore new ways of manipulating rare-earth ion-doped ensembles, in order to reach two goals:

- Realize time-bin qudit analysis, by relying on spectrally chirped AFC. This would unlock the use of large-alphabet encoding in quantum communication protocols.
- Realize the world first implementation of backward emission in AFC protocol, opening a regime of high-efficiency storage of quantum excitations.

In order to reach these objectives, the setup will rely on currently developed ridge waveguides on Pr:Y_2SiO_5 bonded to a silica substrate (project funded by an ANR JCJC program, see figure for a world first realization). The samples will then be cooled down to <4K for spectroscopic characterization in an in-house built cryostat. In parallel to these tasks, a setup for longitudinal addressing of the ions with a stabilized laser will be built.

Work environment.— The PhD will be done at the Institut de Physique de Nice. The applicant will work in the team 'Quantum Information and Photonics', a worldwide renowned team in quantum photonics. This project will be done within two PEPR projects part of the 'plan quantique' (QMEMO and QuCommTestbed), **ensuring funding for the PhD**.

Required background.— The applicant should have a solid background on quantum physics, in particular in light-matter interaction, quantum optics and non-linear optics. An experience in experimental optics would be a strong asset.

Contacts.— Applicants must send a CV and a motivation letter to Jean Etesse :
`jean.etesse@inphyni.cnrs.fr`, +33 (0) 4 89 15 28 46
Scientific advisor of the PhD will be Sébastien Tanzilli :
`sebastien.tanzilli@inphyni.cnrs.fr`, +33 (0) 4 89 15 28 66