**Proposition de thèse 2016-2019**

**Erbium doped materials for quantum optical processing**

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**Description du projet :** Erbium doped materials for quantum optical processing

Rare-earth ion doped crystals have useful properties that can be exploited in the context of quantum information. Optical and spin ion transitions have long coherence times at low temperature so they can make "good" atomic qubits. In solids, the luminescent centers are highly concentrated so the absorption is significant over a large bandwidth making these materials well suited for broadband processing [Dajczgewand15]. This is crucial for the realization of optical quantum memories. We are currently working with an erbium doped $\text{Y}_2\text{SiO}_5$ crystal ($\text{Er}^{3+}:\text{Y}_2\text{SiO}_5$) for which we have demonstrated a large memory efficiency in the C-band of the telecommunication wavelength range [Dajczgewand14].

This level of control allows now to consider experimentally the storage of non-classical light. For this purpose, we propose to focus on the so-called continuous variable (CV) regime of quantum optics. The CV sources in the telecom band has been extensively developed and integrated lately. They are well adapted to erbium doped materials. Their bandwidth correspond to our recent storage demonstration. They are also potentially spectrally multimode thus covering the remarkably high number of frequency channels available in $\text{Er}^{3+}:\text{Y}_2\text{SiO}_5$. The adaptation of a CV source to erbium samples will be conducted with the best national experts in the field.

In parallel to this finalized project, we also propose to investigate experimentally the spin properties of the erbium ion. This requires the direct radio-frequency (RF) excitation of the erbium electron spin by using the techniques developed for Electron Paramagnetic Resonance (EPR) spectroscopy combined with an optical detection. This study opens many perspectives. This allows first to perform an efficient optical pumping assisted by RF to prepare the erbium ensemble in a well defined spin state which is an important ingredient of many quantum storage protocols [Chanelière10]. The opto-RF spin polarization of the sample should be also very beneficial to the coherence time. This latter is indeed limited by the erbium-erbium coupling. The interaction cannot be neglected to evaluate the memory performances [Dajczgewand15]. The sample spin polarization, that can be seen as an effective cooling, will literally freeze the erbium-erbium mutual flip-flop thus reduction the magnetic disturbance as the main source of decoherence.

**Références :**

