

## Master thesis/Internship proposal

### Novel rare-earth materials for quantum technologies

#### Laboratory :

Université PSL - Chimie ParisTech, Institut de Recherche de Chimie Paris (IRCP),  
Crystals and Quantum State Dynamics group ([CQSD](#))  
11 Rue Pierre et Marie Curie, 75005 Paris

#### Project :

The goal of the project is to develop a novel crystalline material useful quantum information processing. CQSD group has strong expertise in growth and synthesis of state-of-the-art rare-earth ion doped materials including nanocrystals and thin films with unique coherent properties in optical and spin domains [1]. They have been extensively used for various quantum technologies including optical quantum memories [2,3], single ion detection [4] and single spin interface [5]. To extend the potential of these platform for quantum applications the investigation of new host materials and their optimisation is needed. The emphasis of this project will be in the growth and coherent spectroscopic characterisation of novel rare-earth ion doped crystals.

Rare-earth ion-doped oxide crystals constitute a promising solid-state platform for optical quantum memories, quantum transducers, and single-photon sources. Broadband operation requires the use of electronic spin systems, which can be efficiently coupled with other platforms. Simultaneous clock transitions for optical and spin domains using  $^{171}\text{Yb}^{3+}$  doped materials [6] offer the possibility to realise broadband optical quantum memory [7]. The investigation of novel host materials is particularly important to minimise further decoherence processes and achieve efficient interfacing between optical and microwave domains.

The student's tasks will include:

- Acquire the skills for growth and material synthesis of rare-earth materials.
- Perform optical and microwave coupling of new materials at cryogenic temperature.
- Realise coherent optical and spin spectroscopy.
- Perform modelling of the decoherence mechanisms and crystalline structure.

[1] T. Zhong and P. Goldner, *Nanophotonics* **8**, 2003 (2019).

[2] F. Bussi eres, C. Clausen, A. Tiranov, B. Korzh, V. B. Verma, S. W. Nam, F. Marsili, A. Ferrier, P. Goldner, H. Herrmann, C. Silberhorn, W. Sohler, M. Afzelius, and N. Gisin, *Nat. Photonics* **8**, 775 (2014).

[3] M. Businger, L. Nicolas, T. S. Mejia, A. Ferrier, P. Goldner, and M. Afzelius, *Nat. Commun.* **13**, 6438 (2022).

[4] C. Deshmukh, E. Beattie, B. Casabone, S. Grandi, D. Serrano, A. Ferrier, P. Goldner, D. Hunger, and H. de Riedmatten, *Optica* **10**, 1339 (2023).

[5] Z. Wang, L. Balembois, M. Ran ic, E. Billaud, M. Le Dantec, A. Ferrier, P. Goldner, S. Bertaina, T. Chaneli ere, D. Esteve, D. Vion, P. Bertet, and E. Flurin, *Nature* **619**, 276 (2023).

[6] A. Ortu, A. Tiranov, S. Welinski, F. Fr owis, N. Gisin, A. Ferrier, P. Goldner, and M. Afzelius, *Nat. Mater.* **17**, 671 (2018).

[7] M. Businger, A. Tiranov, K. T. Kaczmarek, S. Welinski, Z. Zhang, A. Ferrier, P. Goldner, and M. Afzelius, *Phys. Rev. Lett.* **124**, 053606 (2020).

**Who are we looking for? :**

The candidate is expected to have:

- Background in optics, solid-state physics, or optoelectronics, including experimental skills
- Basic knowledge of quantum physics and quantum information
- Interest in experimental work and optical spectroscopy
- Ability to work independently and in daily collaboration with the international research team

**About us :**

Institut de Recherche de Chimie Paris (IRCP) is one of the leading CNRS chemistry laboratories in the Paris region. The group "Crystals and Quantum State Dynamics" ([cgsd.fr](http://cgsd.fr)) is internationally recognized for developing rare-earth ion doped materials for applications in quantum technologies. Our team has extensive experience in the design, growth, and characterization of bulk, thin films and nanoscale crystals, as well as diamond films containing colour centres for applications in photonics and quantum sensing.

We offer creative and stimulating working conditions in a dynamic and international research environment, with access to a wide range of cutting-edge experimental techniques including high resolution coherent spectroscopy, structural analysis and nanofabrication facilities.

**Project responsible :**

Please send applications to Alexey TIRANOV ([alexey.tiranov@chimieparistech.psl.eu](mailto:alexey.tiranov@chimieparistech.psl.eu))