

Proposition de stage / Internship proposal

Date de la proposition : 29/09/2026

Responsable du stage / internship supervisor:

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Nom du Laboratoire / laboratory name: Institut Langevin – Ondes et Images

Etablissement / institution : CNRS/ESPCI Code d'identification : UMR7587

Site Internet / web site: https://www.institut-langevin.espci.fr/atomic_processors

Adresse / address: 1 rue Jussieu, 75005 Paris

Lieu du stage / internship place: idem

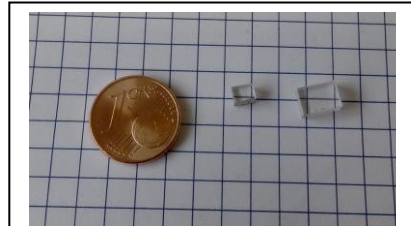
Advanced spectroscopy of rare-earth-doped crystals for quantum sensing and analog processing

The Langevin Institute develops advanced applications in quantum sensing, quantum memories and analog signal processing, harnessing light-matter interaction in rare-earth-doped crystals. These crystals, operated at cryogenic temperatures (around 3K), must meet stringent specifications for the optical linewidth, population lifetimes, and excitation-induced decoherence to ensure optimal performance.

To date, Tm:YAG and Er:YSO have been the preferred choices, enabling breakthroughs such as an industrial demonstrator for spectral analysis of radio-frequency signals [1]. However, the limitations of commercial cryogenic solutions (such as vibrations and cooling power) degrade the nominal properties of the crystals, particularly during ion preparation [2]. This directly impacts the efficiency and dynamics of signal processing, motivating the search for alternative solutions.

The goal of this internship is to explore alternative crystalline matrices (e.g., YGG, co-doped crystals, molecular crystals, ceramics, waveguides) or innovative geometries (e.g. waveguides, mechanical resonators), capable of:

- **Extended population lifetimes at a given temperature** (reducing required laser power and thermal load);
- **Enhanced vibration damping** (e.g. via softer materials);
- **Optimized guiding for light to effectively extend the optical path within the sample** while preserving strong light-matter interaction. This approach would allow working with lower ion concentrations, thereby limiting excitation-induced decoherence.



Some rare-earth doped crystals available in the lab

The intern will perform advanced spectroscopic measurements in the lab (photon echo, time-resolved spectral hole-burning, etc.). These techniques will enable precise characterization of crystal properties: optical absorption, population lifetimes, and decoherence mechanisms, using experimental optical setups (tunable lasers, ultra-sensitive detectors, and laboratory cryogenics).

This internship is particularly suitable for M1 or M2 students or engineering school students specializing in optics or physics. A strong interest in experimental work is essential. Knowledge of lasers and/or light-matter interaction will be valued to confidently tackle the project's technical challenges.

The targeted applications, such as quantum memories, quantum sensing or wideband atomic processors, provide a stimulating and practical context. By actively participating in these measurements, the intern will gain comprehensive, hands-on experience at the heart of a dynamic research project conducted in collaboration with an academic partner (IRCP) and an industrial partner (Thales Research&Technology). A good team spirit, as well as communication skills are therefore mandatory.

[1] P. Berger, et al. (2016). RF spectrum analyzer for pulsed signals: ultra-wide instantaneous bandwidth, high sensitivity, and high time-resolution. *Journal of Lightwave Technology*, 34(20), 4658-4663.

[2] A. Louchet-Chauvet, et al. (2019). Piezospectroscopic measurement of high-frequency vibrations in a pulse-tube cryostat. *Review of Scientific Instruments*, 90(3).