INTERNSHIP PROPOSAL

(One page maximum)

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Internship location: 1 rue Jussieu, 75005 PARIS

Thesis possibility after internship: YES
Funding: YES If YES, which type of funding: ANR

Inertial quantum sensing based on optomechanical coupling in rare-earth-doped crystals

Developing a **broadband, high-sensitivity accelerometer operating at cryogenic temperatures** is a key challenge in many cutting-edge experimental physics domains, from quantum technologies (including near-field microscopy, quantum memories, etc.) to gravitational wave detection. To realize such a sensor, a promising approach is **hybrid optomechanics,** which couples quantum and mechanical degrees of freedom in a single physical system.

Rare-earth ion-doped crystals, known for their extremely narrow optical transitions at low temperature (~3K), exhibit natural optomechanical coupling through the piezospectroscopic sensitivity of the ion's energy levels to mechanical stress (see Figure). These crystals have recently emerged as strong candidates for quantum-enabled, low-temperature accelerometry, and we recently demonstrated **continuous optical measurement of cryostat vibrations** with such crystals, with an already promising sensitivity and bandwidth [1,2].

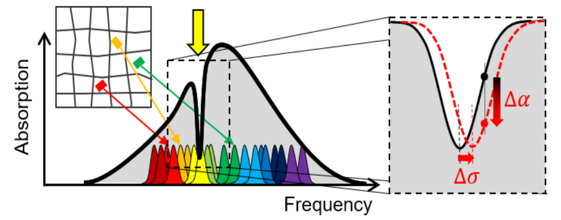

Figure : Left: spectral holeburning revealing the narrow linewidth of rare-earth ions embedded in a crystal. Right: the mechanical stress $\Delta\sigma$ dynamically shifts the spectral hole, leading to a variation of absorption on the side of the hole.

However, significant work is needed to obtain an **ultra-sensitive, unidirectional and calibrated accelerometer**.

During this internship, we will investigate the fundamental and technical limitations of the method (in terms of sensitivity and bandwidth in particular), using emulated or real vibrations. Additionally, we aim to extend the operational range to higher temperatures (up to 10K), which will be key for expanding the potential applications of our sensor.

Methods and techniques: Spectral hole burning, stable lasers, closed-cycle cryostats.

The applicant should have background knowledge in one or several of the following fields: quantum mechanics, light-matter interaction, laser physics and/or condensed matter physics. A taste for experimental physics and teamwork is expected, as well as a good level of English. Basic programming skills are appreciated (e.g. Matlab).

Condensed Matter Physics:	YES	Soft Matter and Biological Physics:	NO
Quantum Physics:	YES	Theoretical Physics:	NO