

# **INTERNSHIP PROPOSAL**

*(One page maximum)*

Laboratory name: Laboratoire Kastler Brossel - Sorbonne Université / CNRS  
CNRS identification code: UMR 8552  
Internship director's surname: JACQMIN, Thibaut  
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Internship location: LKB, 4 place Jussieu, 75005 Paris  
Thesis possibility after internship: YES  
Funding: YES If YES, which type of funding: ANR GRAVITATION

## **Hybrid quantum systems combining mechanical resonators and superconducting circuits**

Summary (half a page maximum)

How can we bring a mechanical object into the quantum regime? High-Q microfabricated resonators coupled to superconducting circuits offer a platform for sensitive force measurements and experiments at the interface between quantum physics and gravity.

The main objective of the internship is the optical characterization of silicon-nitride membranes and ribbons, structured or unstructured. The student will use a digital holographic microscope to map deformations and mechanical mode shapes, and laser interferometers to measure resonance frequencies, thermal motion and quality factors. Finite-element simulations will help identify dissipation mechanisms and select devices.

In a second stage, selected resonators will be coupled to superconducting circuits and measured in a dilution refrigerator near 10 mK. The student will join the Optomechanics and Quantum Measurements team, building on our results on MHz fluxonium qubits [1], quantum-motion measurements [2], cryogenic electromechanical transduction [3] and phononic-crystal membranes [4]. Phononic crystals are one possible resonator geometry.

A funded PhD within ANR GRAVITATION can follow, targeting ground-state preparation of a high-Q mechanical mode and its control at low frequency through dynamic stress tuning.

### References

- [1] B.-L. Najera-Santos et al., “High-Sensitivity ac-Charge Detection with a MHz-Frequency Fluxonium Qubit,” *Physical Review X* 14, 011007 (2024). <https://doi.org/10.1103/PhysRevX.14.011007>
- [2] K. Gerashchenko et al., “Probing the quantum motion of a macroscopic mechanical oscillator with a radio-frequency superconducting qubit,” *arXiv:2505.21481* (2025, revised 2026). <https://arxiv.org/abs/2505.21481>
- [3] H. Patange et al., “Cryogenic rf-to-microwave transducer based on a dc-biased electromechanical system,” *Comptes Rendus. Physique* 27, 49–63 (2026). <https://doi.org/10.5802/crphys.273>
- [4] E. Ivanov et al., “Edge mode engineering for optimal ultracoherent silicon nitride membranes,” *Applied Physics Letters* 117, 254102 (2020). <https://doi.org/10.1063/5.0031626>

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

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