

INTERNSHIP PROPOSAL

Laboratory name: Matériaux et Phénomènes Quantiques

CNRS identification code: UMR 7162

Internship director: Adrien Borne / Ivan Favero

e-mail: adrien.borne@u-paris.fr, ivan.favero@u-paris.fr Phone number: 01 57 27 70 12

Web page: <https://mpq.u-paris.fr/lime/>

Internship location: Bâtiment Condorcet, 10 rue A. Domon et L. Duquet, 75013 Paris

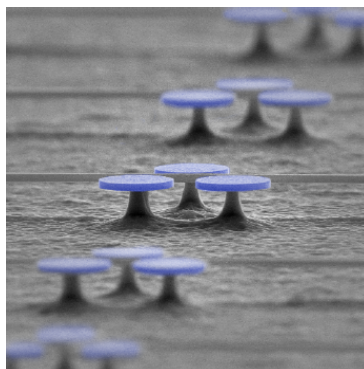
Thesis possibility after internship: YES

Funding: YES If YES, which type of funding: ANR project

Quantum entanglement of mechanical oscillators

Similarly to a single atom, the motion of a massive, mesoscopic-scale mechanical resonator can behave quantum mechanically when cooled down to ultra-low temperatures. The study of quantum states of motion of such system has both fundamental and practical interests: as a test of quantum mechanics in systems beyond the few-particle ensembles, and its interplay with gravitation; or as a light-matter interface for the development of quantum communication networks, for storing and transducing quantum information.

A mechanical resonator, such as the micrometer-sized disks fabricated in our team (picture below), also confines optical modes that strongly interact with the motion. Therefore, light provides a means to shape the quantum state of motion of such an object when prepared close to its ground state (the ‘phonon vacuum’), by adding or removing phonons one by one. Light also probes the obtained states.



This internship/PhD thesis aims to realize multipartite quantum control, entanglement and superposition, in systems composed of several of these optomechanical resonators, either evanescently coupled or arranged in an interferometric configuration. This work will target in particular the generation of maximally-entangled GHZ states, of importance in quantum computing protocols, or N00N states, of interest for sensing with sub-standard quantum limit sensitivity, and offering the possibility to explore the concept of nonlocal influence in quantum mechanics.

Methods and techniques: Quantum optics, nanomechanics, single-photon counting, low temperatures

References:

I. Favero and K. Karrai, Nat. Phot. 3, 201 (2009),

M. Aspelmeyer, T. Kippenberg and F. Marquardt, Rev. Mod. Phys. 86, 1391 (2014)

S. Barzanjeh, Nat. Phys. 10, 1038 (2014)

A. Barbero, S. Pautrel, ..., A. Borne, I. Favero (2025).

Condensed Matter Physics: YES

Quantum Physics: YES

Soft Matter and Biological Physics: NO

Theoretical Physics: NO