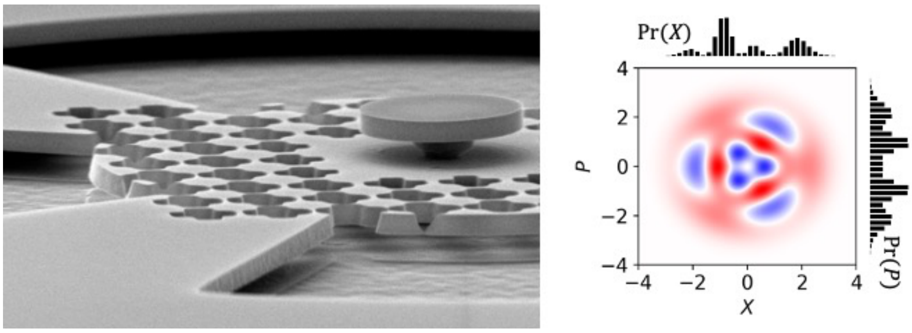
INTERNSHIP PROPOSAL

Laboratory name: Matériaux et Phénomènes Quantiques
CNRS identification code: UMR 7162
Internship director’surname: Adrien Borne
e-mail: adrien.borne@u-paris.fr Phone number: 01 57 27 70 12
Web page: https://mpq.u-paris.fr/en/lime-en/
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 CREATION

Quantum states of motion of a mechanical resonator

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



Left: Scanning electron microscope image of an optomechanical disk resonator mechanically shielded from the environment (nanofabrication by our team). Right: Theoretical Wigner function of a superposition state.

In this context, this internship/PhD project aims at generating targeted quantum states of the motion of an optomechanical resonator such as the microdisk pictured above and developed in our group [1]. Fock and coherent superposition states will be considered, chosen arbitrarily in the low phonon number regime. This mechanical quantum information can be encoded in the device through its interaction with light [2,3], and then characterized through optical tomographic reconstruction [4]. This work will also consider increasing the dimensionality by including several optomechanical resonators, thereby involving entanglement of massive objects.

[1] M.R. Vanner, M. Aspelmeyer and M.S. Kim, PRL **110**, 010504 (2013).
[2] I. Favero and K. Karrai, Nat. Phot. **3**, 201 (2009).
[3] M. Aspelmeyer, T. Kippenberg and F. Marquardt, Rev. Mod. Phys. **86**, 1391 (2014).
[4] M.R. Vanner, I. Pikovski, and M.S. Kim, Ann. Phys. **527** (2015).

Methods and techniques: Quantum optics, nanomechanics, single-photon counting, quantum state tomography, cryogenics

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