INTERNSHIP PROPOSAL

(One page maximum)

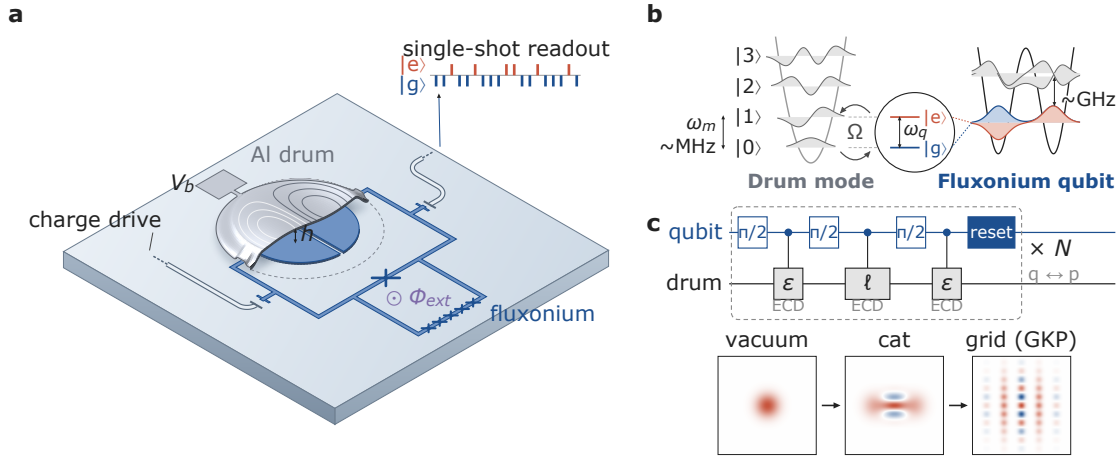
Laboratory name: Laboratoire de Physique de l'École Normale Supérieure (LPENS)
CNRS identification code: UMR 8023
Internship director's surname: DELÉGLISE, Samuel
e-mail: samuel.deleglise@cnrs.fr
Web page: https://quantic.phys.ens.fr/
Internship location: Quantic team, LPENS, 24 rue Lhomond, 75005 Paris
Thesis possibility after internship: YES
Funding: YES If YES, which type of funding: INRIA grant

Storing quantum information in the vibration of a drum

Mechanical resonators can store quantum states for long times: aluminium drums a few tens of micrometres across, suspended above a chip, vibrate at megahertz frequencies with energy lifetimes of seconds and negligible dephasing [3]. Controlling them at the level of single quanta requires a nonlinear element at the same frequency. Our team has developed such an element, the heavy fluxonium, a superconducting qubit with a transition frequency around 1 MHz, about a thousand times lower than conventional superconducting qubits, and has used it to read out and cool the motion of a mechanical resonator [1,2].

During the internship, the student will design a drum–qubit chip with a coupling large enough for drum and qubit to exchange single quanta of vibration (strong-coupling regime), combining electromechanical and circuit modelling. The student will also become familiar with our ongoing experiments on fluxonium–mechanical devices at 10 mK, and with the microwave techniques used to operate them. This design is the starting point of the PhD.

The PhD will then address the preparation of Schrödinger-cat states of a megahertz mechanical mode, and the encoding of an error-protected quantum bit in the motion of the drum (figure).



(a) Aluminium drum, biased at V_b, driving a fluxonium qubit (blue). (b) Drum and qubit share the same megahertz level spacing and exchange quanta at rate Ω. (c) Qubit-controlled displacements turn the ground state of the drum into a cat state, then into a grid state that encodes a protected quantum bit.

References

[1] B.-L. Najera-Santos *et al.*, "High-sensitivity ac-charge detection with a MHz-frequency fluxonium qubit," Phys. Rev. X **14**, 011007 (2024).

[2] K. Gerashchenko *et al.*, "Probing the quantum motion of a macroscopic mechanical oscillator with a radio-frequency superconducting qubit," arXiv:2505.21481 (2025).

[3] A. Youssefi *et al.*, "Compact superconducting vacuum-gap capacitors with low microwave loss and high mechanical coherence for scalable quantum circuits," Phys. Rev. Applied **23** (2025).

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