NEEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2024-2025

Ultra-cold Nanomechanics

Keywords: quantum mechanics, nano-mechanics, non-linear phenomena, low temperatures, ground-state cooling, stochastic thermodynamics

General Scope:
The project is devoted to fundamental research using nanomechanics cooled down to the lowest possible temperatures. It has two facets: a macroscopic approach concerned with the quantum mechanics behavior of the moving device itself, and a microscopic one concerned with elementary excitations in quantum matter and thermodynamics concepts.

Research topic and facilities available:
The project is based on the « brute force » cooling of nanomechanical devices down to temperatures below 1 mK. For devices resonating around 20 MHz in their first flexure, the collective modes describing the motion are in *their quantum ground states*. Experiments probing mechanical quantum coherence are then possible, on a system which is at equilibrium with the environment. These coherence properties are linked to fundamental aspects of quantum theory, with new developments (e.g. stochastic collapse) and old paradoxes (e.g. Schrödinger cat).
Properties of quantum matter are probed by looking at intrinsic mechanical dissipation mechanisms in the constitutive solids, and more specifically at *their fluctuations*. These are characteristic of the thermodynamic baths connected to the mechanics, and tells us about fundamental aspects of thermodynamics.
These experiments rely on cryogenic capabilities of the group: a unique platform allying demagnetization cooling down to 500 µK with a quantum-limited microwave optomechanical readout (see Figure).

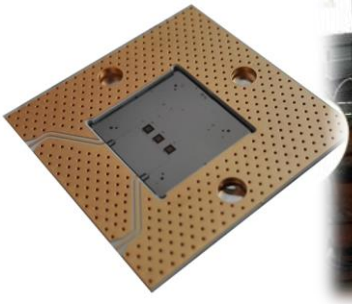

Figure: A PCB board hosting a microwave optomechanics experiment (left) and the nuclear demag. cryostat (right).

Possible collaboration and networking:
This research is carried out at Institut Néel, in collaboration with other researchers from the laboratory. It is performed in the framework of the *European Microkelvin Platform (EMP,* web.emplatform.eu*)*, with contacts to other ultra-low temperature facilities in Europe (UK, Germany, Finland…). Theoretical support is provided by collaborators from Nottingham University, UK.

Possible extension as a PhD: yes

Required skills:
The student should have a strong interest in fundamental research and making challenging measurements at very low temperatures, as well as a thorough understanding of quantum theory at the Master's Degree level.

Starting date: Flexible

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