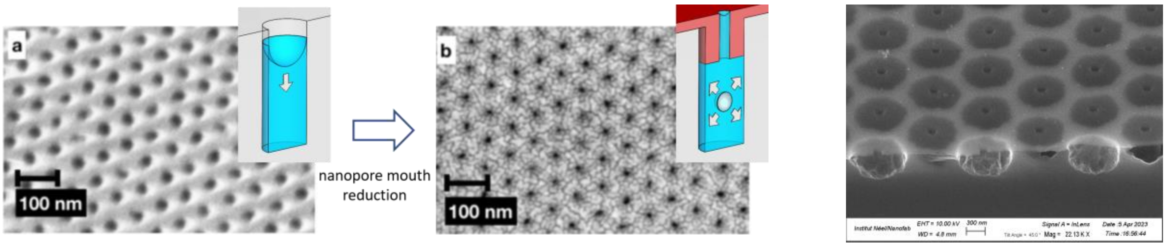
NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2023-2024

Cavitation in superfluid helium

General Scope:
Cavitation, the nucleation of a vapor bubble in a stretched liquid, is a ubiquitous phenomenon, from engineering to natural sciences. Our team has recently used an experimental method to induce cavitation inside nanopores (see figure below). Our results show that cavitation occurs in conventional fluids via the thermally activated formation of a bubble nucleus as decribed by the Classical Nucleation Theory (CNT)[1,2], provided that the surface tension is corrected for nanometric bubbles[3] and the diameter of the pores is not too small. However, the situation is still confused for superfluid helium where quantized vortices could act as preferential sites[4] for nucleation.



SEM pictures. Left: in native alumina nanopores, evaporation unfolds through meniscus recession. Center: after pore mouth reduction, the meniscus is pinned and cavitation is induced. Right: SiN/Si artificial porous system developed at Nanofab (coll. T. Crozes).

Research topic and facilities available:
To study the influence of quantum effects on cavitation, we are developing an artificial porous system using recent progresses in nanolithography techniques. The successful candidate will use a highly sensitive capacitive detection technique to study helium cavitation into the superfluid phase. In parallel, the influence of confinement on cavitation will be explored.

Possible collaboration and networking:
This work is part of the project NANOCAV supported by ANR. In this framework, part of the fabrication and specific measurements will be done at Ecole Normale Supérieure in the group of Etienne Rolley (LPS-ENS, Paris).

Possible extension as a PhD: yes, funding available

Required skills:
This project is at the crossroads of low temperature and statistical physics, focusing on porous materials. Experiments combine nanolithography, cryogenics and transport techniques. A solid background in condensed matter physics (including statistical physics and/or soft matter) is required.

Starting date: flexible to the trainee academic program
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[1] Doebele et al, Direct observation of homogeneous cavitation in nanopores, PRL 2020
[2] Bossert et al, Evaporation process in porous silicon: cavitation vs pore-blocking, Langmuir 2021
[3] Bossert et al, Surface tension of cavitation bubbles, PNAS 2023
[4] Djadaojee et al, Brillouin Spectroscopy of Metastable Superfluid Helium-4, PRL 2022