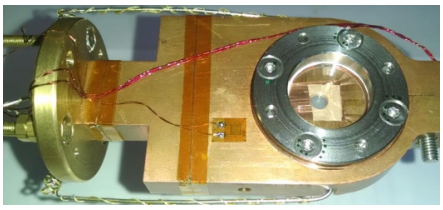
NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2020-2021

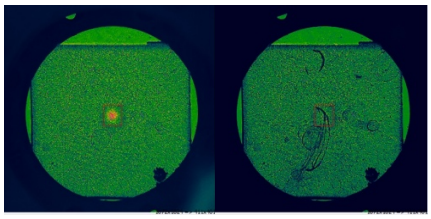
Probing the Classical Nucleation Theory of cavitation with helium

General Scope: Cavitation, the thermally activated nucleation of a vapor bubble in a stretched liquid, is a ubiquitous phenomenon, from engineering to natural sciences. Away from surfaces, cavitation is expected to obey the homogeneous Classical Nucleation Theory (CNT). Up to recently, precise checks only relied on transient, acoustically driven, cavitation. In contrast, an alternative, static, method introduced in 2008 [1], the so-called artificial tree technique, failed to confirm the CNT. Using a forest of such trees, tailored in a nanoporous alumina membrane, we recently provided the first experimental verification of the CNT based on the artificial tree concept [2]. This result opens the way to further studies, such as understanding the influence of nanoconfinement on cavitation, or, using helium as a fluid, the possible influence of quantum effects on cavitation.



Left : Cell for helium measurements.

Right: optical detection of hexane cavitation in an alumina membrane



Research topic and facilities available: The candidate will contribute to the development of cavitation studies of helium at cryogenic temperatures. He/she will take part to experiments on helium cavitation in nanoporous alumina membranes, so as to become familiar with the involved concepts and cryogenics. In parallel, using room temperature hexane as a fluid, and an existing set-up, he/she will test different schemes for building a single artificial tree device, that is a macroscopic cavity connected to the external world through a nanoporous plug [1]. Time permitting, he/she will integrate capacitive measurements of the liquid density and pressure to the device, with the long-term goal of measuring the equation of state of helium at negative pressures down to the cavitation threshold.

Possible collaboration and networking:
This project involves a close collaboration (funded by ANR) with partners in Paris (LPENS and INSP). We also interact with colleagues in Lyon (ILM), Grenoble (LiPhy), in France, and Padova in Italy.

Possible extension as a PhD: yes

Required skills: A solid background in condensed matter physics (including statistical physics and/or soft matter) is required. The candidate should also have a broad interest for physics and experimental techniques (thermodynamic concepts, materials synthesis and characterization, capacitive and optical measurements, cryogenics, …), be self-motivated and have a strong curiosity about new phenomena.

Starting date: Any time in the year

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[1] Wheeler T. D. and Stroock A. D., The transpiration of water at negative pressures in a synthetic tree, Nature 455, 208 (2008).
[2] Doebele V., et al, Direct observation of homogeneous cavitation in nanopores, https://arxiv.org/abs/2007.03521