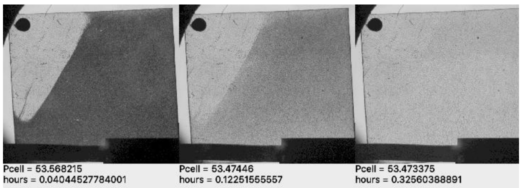
NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2019-2020

Helium cavitation using the artificial tree technique

General Scope: Cavitation, the thermally activated nucleation of a vapor bubble in a stretched liquid, is a phenomenon occurring in many fields, ranging from engineering to natural sciences. Its occurrence is expected to follow the Classical Nucleation Theory (CNT). Our goal is to test this expectation by using the so-called artificial tree technique**,** where a liquid contained in a cavity is connected to a vapor reservoir through a narrower constriction, also filled with liquid. Decreasing the vapor pressure brings the liquid below its saturated pressure, even possibly at negative pressure (i.e. the liquid is stretched). If the constriction is narrow enough (typically 5 nm in diameter) for capillarity to stabilize the liquid confined inside, the cavity empties by cavitation. While cavitation is a generic phenomenon, an ideal model fluid to test CNT is helium at cryogenic temperatures, because this allows to easily explore a wide range of temperatures and thus probe the activated nature of the cavitation process. We recently demonstrated hexane and helium cavitation in a microscopic version of the artificial tree, consisting of alumina membranes presenting arrays of microscopic cavities, coupled to the vapor reservoir through independent nanometric constrictions.



Optical signature of the stochastic nature of hexane cavitation in naporous alumina membranes

Research topic and facilities available:
We now want to develop a macroscopic version, using a centimeter size cavity connected to the vapor reservoir through a nanoporous plug. Such a geometry will allow to directly measure the intra-cavity liquid pressure using a deformable diaphragm, and to quantitatively probe the CNT without any assumption on the equation of state of helium at negative pressures.
The intern will use a simple approach (etching of a cavity in a glass slide, and sealing by a porous silicon membrane) to fabricate a first generation device. Using existing set-ups, the intern will test this device at room temperature using hexane as a fluid, then at cryogenic temperatures using helium. Cavitation will be detected either optically or through volumetric measurements.

Possible collaboration and networking:
This project falls in the framework of an ANR project and will involve collaboration with our partners in Paris (LPENS and INSP). A collaboration with ILM (Lyon) is also foreseen.

Possible extension as a PhD: Yes (second generation device allowing to measure the liquid density and pressure as a function of the reservoir pressure, i.e. the chemical potential).

Required skills: Experiments combine cryogenics and optical techniques. A good knowledge of general physics (including thermodynamics and optics) is required, as well as a solid background in condensed matter physics (including statistical physics and/or soft matter). The candidate should be self-motivated and have a strong curiosity about new phenomena.

Starting date: Any time in the period

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