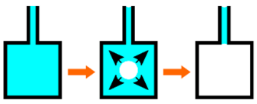
NÉEL INSTITUTE Grenoble

Topic for Master 1 internship – Academic year 2019-2020

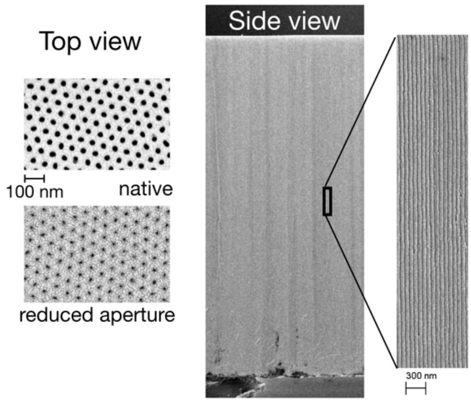
Cavitation in nanoconfinement

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. For most fluids, the radius of the critical germ is of the order of one to several nanometers. One thus expects cavitation to be hindered in nanoporous materials with pores diameters lying in this range, with a direct impact on the nature of the evaporation mechanism in such materials. Our goal within the ANR project CAVCONF is to measure the effect of confinement on the cavitation pressure, and to compare the results to existing theories, using nanoporous alumina membranes as a model material. These membranes present billions of parallel pores, the diameter of which can be tailored between typically 10 and 100 nm. These pores are open at one end on a vapor reservoir. We have recently developed a technique to reduce their aperture diameter, which stabilizes the liquid phase in the resulting constriction. Decreasing the vapor pressure brings the liquid inside the pores below its saturated pressure, allowing to reach negative liquid pressures and cavitation. We thus demonstrated helium and hexane cavitation in such membranes with nanopores diameters of order 30 nm, still a too large value to observe an effect of confinement.

Cavitation in constricted pores



MEB image of an alumina membrane



Research topic and facilities available:
Our goal is to further reduce the pore diameter so as to observe and quantify the effect of confinement. This requires to obtain smaller pores diameters, which we plan to achieve using controlled atomic layer deposition of alumina on the pore surface. The intern will test this approach by performing cavitation experiments at room temperature, using hexane as a fluid and an existing set-up. Obtaining pores with a final small and well-defined diameter may be challenging if the surface of the native pores is rough at the nanoscale. In this case, new fabrication techniques or alternative porous systems will be studied in the framework of the internship.

Possible collaboration and networking:
This project will involve collaboration with our ANR partners in Paris (LPENS and INSP).

Required skills: A good knowledge of thermodynamics and optics is required, as well as a 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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