Dynamic and stability of superhydrophobic surfaces

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Superhydrophobic surfaces (SHS) are bioinspired surfaces (from lotus leaves) able to repel water through the synergy of microroughness and hydrophobicity. When immersed in water, such surfaces can trap an air layer inside the microstructure, a layer called plastron, opening the avenue for drag reduction application thanks to the significant slip length water experiences on the plastron. However, this air layer can become unstable under pressure fluctuations or in turbulent flow conditions. Indeed, under strong enough mechanical stress, the microstructure can be flooded, i.e. superhydrophobicity breaks down, and the drag reduction properties are lost.

The aim of this postdoc is to elucidate the dynamical conditions under which a plastron becomes unstable. This study is part of a bigger project (ANR IDEFHYX) which aims at understanding the coupling between turbulent flow and plastron dynamic.

Two typical experiments will be carried out : 1) plastron destabilization by a shear flow (figure 1) and 2) characterization of the plastron dynamic (figure 2). The first experiment mimics flow conditions in drag reduction application. Plastron destabilization under different shear will be monitored by light interferometry or laser vibrometry. The main objective is to dentify the mechanism, potentially a Kelvin-Heltmoltz like instability, underlying superhydrophobicity break-down.

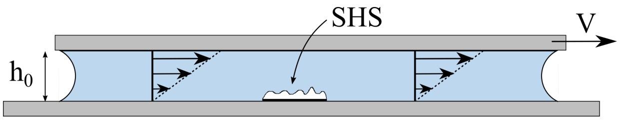

Figure 1 : Schematic of the experiment of plastron destabilization under shear flow

In turbulent flow, a plastron is subjected to a broadband spectrum of vibrations, which can potentially excite several resonances of the air layer. A second experiment will therefore be dedicated to the characterization of the plastron eigen modes ranging from low frequency modes (whole air layer) using mechanical vibrations to high frequency modes at the roughness scale using acoustic waves (Figure 2 (a) & (b)). Coupling between flow fluctuations and capillary waves were numerically predicted as a possible origin of destabilization. Using a similar setup with focused acoustic waves, propagating capillary waves at the surface of the plastron will also be studied (Figure 2 (c) & (d)).

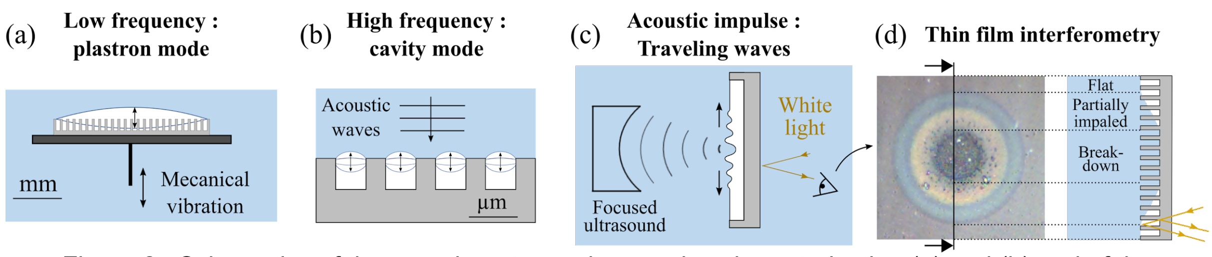

Figure 2 : Schematics of the experiments on eigenmodes characterization (a) and (b) and of the travelling capillary waves (c) and (d).

We are looking for an experimentalist with a fluid mechanics background (capillarity, instability, waves,…). The postdoc will build the different setups which require experimental skills in high speed imaging, light interferometry and electronic equipment.