Title	Numerical simulation of the deformation of a gas-liquid interface in contact with a super-hydrophobic surface in a shear flow
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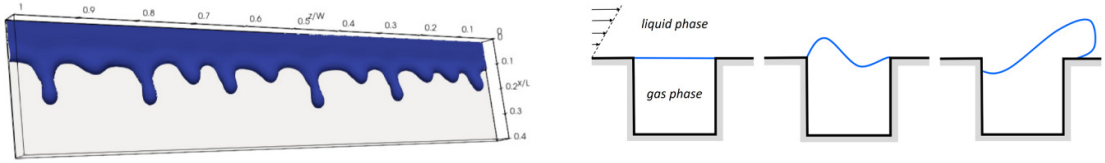
Context

Among the large variety of materials fashioned for industrial needs, super-hydrophobic surfaces (SHS) have attracted increasing attention since the last twenty years (Rothstein 2010). Their physicochemical properties enable SHS to entrap a gas layer, referred to as plastron, in their roughness restricting thereby the solid-liquid contact area. This lubricating feature leads to liquid repellency, the so-called "Lotus effect", which may strongly impact a wide range of engineering applications where wettability control is essential.

Although extremely attractive for flow control purposes, SHS suffer from severe drawbacks limiting their performances in realistic conditions. Among arising issues, the stability of the air-water interface is a cornerstone to warrant SHS efficiency and sustainability. For instance, the effects of external perturbations leading to plastron depletion in turbulent flows are still unclear if not ignored in most widespread models currently available to mimic SHS properties (Castagna *et al.* 2018).

These PhD project aims at overcoming these issues by using a two-phase flow simulation tools, in order to provide an in-depth understanding of the physical mechanisms governing the interaction between the gas-liquid interface and its surrounding environment. This PhD work is part of the ANR project IDEFHYX (modelling the Interface DEFormation on super-HYdrophobic surfaces in eXtreme conditions), in collaboration with PRISME, DYNFLUID and MSC laboratories.



(a) (b)

Figure 1 : (a) simulation with the JADIM code at IMFT of the spreading of a liquid film on a solid surface (Lavale et al. 2020). (b) Schematics of the dynamics of the gas-liquid interface depending on the local shear rate (from left to right) : static case, moderate deformation, contact lines motion.

Objectives

The JADIM code, developed at IMFT, uses a front capturing technique which allows for the computation of multiple interfaces on a fixed grid (figure 1a). It includes a dynamic contact line model which describes the motion of the interface in contact with the solid surface (Legendre & Maglio 2013). Another module, denoted immersed boundary method, allows for the computation of the flow around solid objects of arbitrary shape (Gsell *et al.* 2016).

The objective of the present PhD project is twofold. First, it consists in "coupling" the module of dynamic contact line with the immersed boundary method, so as to simulate the deformation of interfaces in contact with solids of complex shape. Second, it aims at investigating the dynamics of a gas-liquid interface initially present between two roughness constituting the super-hydrophobic surface, as a function of the local shear rate of the ambient flow (figure 1b). Configurations of increasing complexity will be computed, starting from the regime where the interface remains static, a regime with small deformations of the interface and finally a regime with strong deformations and contact line motion. Several parameters will be varied in a relatively wide range (Reynolds number, Weber number, wettability of the solid surface). The JADIM code is parallel, so the project will benefit from the computing resources of the meso-center CALMIP (https://www.calmip.univ-toulouse.fr/). Finally, numerical results will be compared with experimental data obtained within the framework of the ANR project IDEFHYX.

Profile

The PhD candidate should have both a strong background in general fluid mechanics and/or applied mathematics and good skills in computational fluid dynamics.

References

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