Drop impact onto a thin liquid film: extension from two to three phase scenarios using phase-field method

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While the drop impact process onto thin liquid film for identical liquids has been extensively studied both experimentally and numerically, the impact process for non-identical liquids has been received much less attention. For the case when the film liquid is different from that of the drop the immiscibility and miscibility of the liquids play an important factor and can result in completely different spectrum of topological changes that the system undergoes.

In this talk we detail on the extension of our numerical methodology from $N = 2$ to $N > 2$ generic immiscible, incompressible and isothermal phases for numerical simulation of drop impact onto a thin liquid film. We are also working on the extension of our numerical framework to miscible systems. Our methodology is diffuse interface phase-field interface capturing method developed in FOAM-extend 4.1. The phase-field method is an energetic variational formulation originally based on the work of Cahn and Hilliard [1] where the interface is composed of a region of finite thickness resembling realistic interfaces.

Numerical simulations of drop impact onto thin liquid film of another liquid will be presented in this talk. This is considered a direct continuation of our recently published work [2]. Figure 1 depicts preliminary results of interface-resolved direct numerical simulation of a three-phase immiscible flow system compared to in-house experimental results. In this system, a silicone oil drop of diameter 1.44 mm impacts a stagnant water film of 0.5 mm thickness at 2 m/s while the ambient phase is air.

References

[1] Cahn, J. W., & Hilliard, J. E., *Free energy of a nonuniform system. I. Interfacial free energy*, The Journal of Chemical Physics, **28**(2), 258-267, 1958.

[2] Bagheri, M., Stumpf, B., Roisman, I. V., Tropea, C., Hussong, J., Wörner, M., & Marschall, H., *Interfacial relaxation–Crucial for phase-field methods to capture low to high energy drop-film impacts*, International Journal of Heat and Fluid Flow 94 (2022) 108943. doi:https://doi.org/10.1016/j.ijheatfluidflow.2022.108943.

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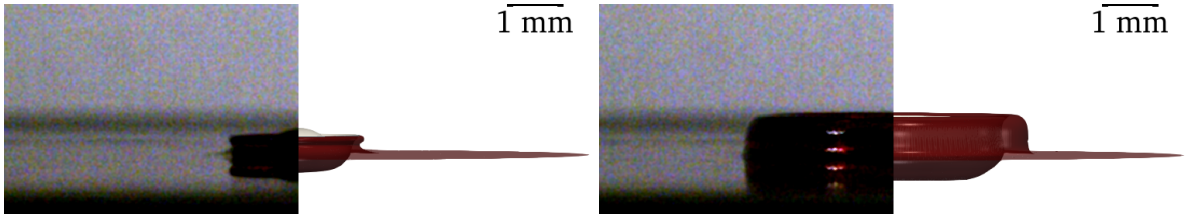

(a) $t = 0.5$ ms (b) $t = 3$ ms

Figure 1: Recordings from the experiments (left) and simulations results (right). Water film is colored maroon and the oil drop is gray.