

Direct Numerical Simulation of Film Boiling around a superheated solid in a Subcooled LiquidGauthier Bourdon^{1*}, Sébastien Tanguy¹, Christophe Airiau¹.¹ IMFT CNRS UMR 5502, Université de Toulouse, 31400, France

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Abstract

Stable film boiling regime around a superheated solid is investigated with Direct Numerical Simulation. Our numerical solver is based on the Level-Set Method to capture the interface motion, and the Ghost Fluid Method to impose the jump conditions across the interface in configurations involving liquid-vapor phase change, as in [1,2]. The solid frontier is described with an immersed boundary method, as proposed in [3], which enables a simple discretization of the solid frontier within the framework of Cartesian grids. In this work, both an incompressible and a variable density solver in the vapor phase are considered. Several intermediate validations have been successfully carried out on benchmarks of increasing complexity, as free convection around a horizontal cylinder, and film boiling around a superheated cylinder in saturated water, as illustrated in Fig. 1. Next, the impact of different liquid subcooling on the Nusselt number has been investigated. Since high superheat between the solid and the interface can lead to strong variations of the density in the vapor phase, constant and variable density simulations are proposed to quantify the impact of density variations on the Nusselt number. As very thin vapor films are involved, strongly refined meshes (until 32 millions of grid points in 2D) are required to perform these simulations. Many relevant information can be extracted of these fully resolved simulations, as the local heat flux variations along the solid interface which depends on the vapor film thickness, or the flow structure in the vapor surrounding the superheated solid. These simulations provide useful data to design integrated models for larger scale simulations.

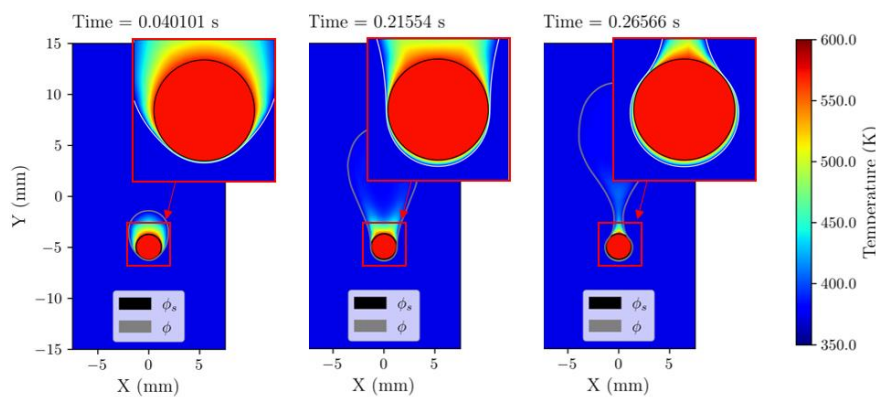


Fig. 1: Snapshots of temperature field and interface shape of film boiling around a superheated solid

[1] Tanguy et al, J. Comput. Phys, 2014, Vol 264, 1-22

[2] Huber et al, Int. J. Heat Mass Transf., 2017, Vol 113, 662-682

[3] Ng et al, J. Comput. Phys, 2009, Vol 228, 8807-8829