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DIFFUSE INTERFACE METHOD FOR DNS OF NUCLEATE BOILING

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Boiling is an efficient mechanism for heat transfer in several industrial applications due to its excellent heat transfer coefficient. These systems are difficult to be described accurately, due to the complex coupling of the hydrodynamics, heat-transfer, and mass-transfer due to non-equilibrium phase-change thermodynamics. Recent development of high performance computating with parallelised numerical simulations enables a detailed study of nucleate boiling phenomena.

We are developing a direct numerical simulation framework using our in-house TPLS Solver [1] using the Diffuse Interface Method [2] which solves the Cahn-Hilliard equation to describe evolution of the liquid-vapour interface. This method removes the stress singularity at three-phase contact line, thereby allowing imposition of a contact angle boundary condition to prescribe surface wettability [3]. This is important in order to understand the role of surface wettability on nucleate boiling heat transfer coefficient, bubble growth and departure.

The growth rates and departure of nucleating single-bubbles as a function of substrate wettability have been obtained through simulations. The modelling framework has also been extended to simulate a multiple bubble population to analyse the bubble interaction, the superheat and bubble size for different wettabilities, as shown in Fig. 1.
Our analysis shows the importance of surface tension on the departure conditions, revealing a better heat removal in high wettability cases. Conversely, a limited growth rate has been reported in low wettability surfaces, which could be more likely to promote the sequent bubble nucleations.

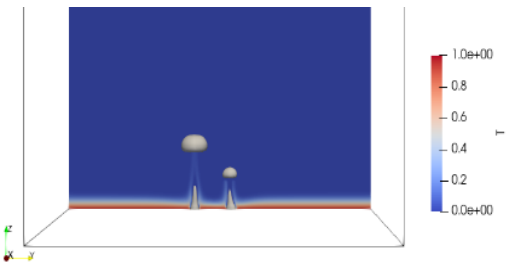

Figure 1. 2D section of temperature profile in a two bubbles simulation.

In order to account for the thermodynamics and hydrodynamics of the liquid microlayer formed beneath a growing vapour bubble, we also propose an improved hybrid-pseudopotential Lattice Boltzmann method applied to a nucleate boiling system [4]-[5], including the Peng-Robinson equation of state.

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