Counter-current thermocapillary migration of bubbles in self-rewetting liquids

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The thermocapillary migration of bubbles has been widely studied since Young's work (J. Fluid Mech. 6, 1959) describing a bubble rising in a quiescent liquid subject to a vertical temperature gradient. Many studies have addressed the effects of viscosity, thermocapillarity and thermal convection on the bubble motion in theoretical and experimental works. However, most studies so far are mainly based on pure liquids that present a linear (decreasing) dependence of surface tension with temperature. In this work, we consider the motion of a bubble in the so-called self-rewetting fluids that have a parabolic dependence of surface tension on temperature with a well-defined minima. In particular, we investigate the counter-current thermocapillary migration of bubbles in self-rewetting liquids under temperature gradient in a range of temperature that includes the surface tension minima. We approach this problem by means of direct numerical simulations (DNS) using the Basilisk solver to address the two-phase conservation of mass, momentum and energy with a Volume-of-Fluid (VOF) method to resolve the deformable interface. We perform a parametrical study to evaluate the effects of viscous and thermocapillary forces on the bubble motion and compare our results with the experimental findings and the theoretical approach reported by Shanahan and Sefiane (Sci. Rep. 4, 2014). Three distinct regimes of counter-current bubble migration are characterized: i) "steady migration" where the bubble migrates against the flow towards the surface tension minima location until it comes to a halt and stay stationary at its equilibrium position; ii) damped oscillations where the bubble oscillates before stay stationary; and ii) "sustained oscillations" where the bubble presents steady oscillations around its equilibrium position. We provide a map in the Reynolds and capillary numbers parameter space with the regions of different bubble behaviours and illustrate how these sustained oscillations arise at low capillary numbers O(10^{-5}).

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References (Times New Roman 10 pt, single line spacing.**)**

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