Thermocapillary-driven motion of a droplet on an inclined substrate: contact line dynamics, and non-monotonic dependence of surface tension on temperature

GEORGE KARAPETSAS, University of Thessaly, KIRTI SAHU, Indian Institute of Technology, Hyderabad, KHELLIL SEFIANE, University of Edinburgh, OMAR MATAR, Imperial College London — We consider the two-dimensional motion of a droplet on an inclined, non-isothermal solid substrate. We use the lubrication approximation to obtain a single evolution equation for the interface, which accounts for gravity, capillarity, and thermo-capillarity, brought about by the dependence of the surface tension on temperature. For the latter, a nonlinear function is used, which exhibits a well-defined minimum. The contact line motion is modelled by coupling the contact line speed to the difference between the dynamic and equilibrium contact angles; the latter vary dynamically during the droplet motion through the dependence of the liquid-gas, liquid-solid, and solid-gas surface tensions on the local contact line temperature. Thus, the local substrate wettability also varies dynamically at the two edges of the drop. A full parametric study is carried out for constant substrate temperature gradients in order to investigate the interplay between Marangoni stresses, induced by thermo-capillarity, gravity, and contact line dynamics in the presence of local wettability variations, and non-monotonic dependence of the surface tension on temperature. The results of this study are presented together with comparisons against experimental data.