Thermal Marangoni migration of droplets in an Oldroyd-B fluid under creeping flow conditions

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In this work we investigate the impact of elasticity on the thermocapillary motion of droplets for the case of vanishing Reynolds and Marangoni numbers, i.e. when inertial terms in the momentum equation and convective-transport contribution in the energy equation are negligible. The study has been carried out employing a coupled Level-Set-Volume of Fluid approach and an adaptive mesh refinement strategy implemented in the framework of the CFD toolbox OpenFOAM. The interfacial stresses induced by a non-uniform temperature distribution at the fluid-fluid interface have been accounted for by adding to the momentum equation an "extra" source term based on the so-called "Continuum Surface Force" approach. The calculation of such contribution requires the knowledge of the temperature field, which makes the momentum and energy equations fully coupled. Here, we consider the case of an initially quiescent droplet placed in a box-shaped domain where a constant temperature gradient is applied under reduced gravity conditions. The imbalance of the interfacial stresses generated by the non-uniform temperature distribution causes the liquid in the proximity of the drop to migrate from the hot to the cold region. This mechanism results in the drop moving in the opposite direction due to the thrust generated by the counter motion of the surrounding phase. For the specific case of a droplet of Newtonian fluid in a viscoelastic surrounding matrix, we use an Oldroyd-B constitutive equation to capture the viscoelasticity of the matrix in the absence of shear-thinning effects. We have investigated the effect of the Deborah number and found the droplet shape and its asymptotic migration velocity deviate significantly from those observed for a Newtonian system. This departure of the observed dynamics from Newtonian behaviour can be ascribed to the complex interplay between different effects, including droplet morphological evolution and related distribution of surface-tension-driven and elastic stresses at the interface.

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