

Effect of Gravity Force on the Long-wave Marangoni Convection in Two-layer Films

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Abstract

The influence of the gravity on the long-wave Marangoni patterns in two-layer films, is considered. The numerical analysis is carried out in the lubrication approximation. We consider a system of two superposed layers of immiscible liquids with different physical properties. The bottom layer rests on a solid substrate, the top layer is in contact with the adjacent gas phase. Evolution equations have been discretized by central differences for spatial derivatives and solved using an explicit scheme. Periodic boundary conditions have been applied on the boundaries of the computational region.

1. We have performed numerical simulations of the nonlinear wavy regimes generated by the oscillatory Marangoni instability, when heating is from above. As it is usual for long wave oscillatory instabilities in the absence of the gravity force, during a long period of time the maximum heights of the upper and lower interfaces change in an irregular way. Finally, periodic oscillations are developed in the system. The snapshots of the isolines show, that the interfaces are subject to some persistent pulsations. For relatively small values of the constant gravity force, the periodic oscillations are retained, but their amplitude is smaller than in the absence of gravity. With the growth of the gravity force, the oscillations are suppressed, and one observes two-dimensional stationary waves. Finally, the Marangoni instability is completely suppressed and the mechanical equilibrium is stable.

2. The evolution of non-isothermic ultra-thin two-layer film under a joint action of thermocapillary effect and intermolecular forces, is considered. The disjoining pressures that lead to the additions to pressures in the bottom layer and in the top one, are taken into the consideration.

The analysis shows that the combined action of the transverse and longitudinal components of the temperature gradient can lead to novel phenomena that are not observed when only one of those components is present. It is shown that the effect of gravity on the film stability can be significant. Specifically, it is found that under the action of the gravity forces, the stable configuration of ordered droplets is destroyed and transforms to new stable configurations of vertical stripes or inclined stripes.

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