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MULTISTABLE MARANGONI CONVECTION IN TWO-LAYER FILMS

Abstract

It is known that multilayer liquid systems are subject to numerous kinds of instabilities. When the layers are sufficiently thin, the Marangoni effect is the main origin of instability. In the investigations of the multilayer Marangoni convection, it is typically assumed that the normal components of the heat flux are equal on both sides of the interface between the fluids. However, there are several physical processes which are characterized by a heat release or heat consumption on the interface. For example, the interfacial heat release accompanies a chemical reaction at the interface and heat consumption accompanies the evaporation. In the present work, we consider the development of the Marangoni instability in a two-layer film in the presence of a transverse temperature gradient and a heat release/consumption at the liquid-liquid interface. The bottom layer rests on a solid substrate, the top layer is in contact with the adjacent gas phase. The surface tension coefficients on the lower and upper interfaces are linear functions of temperature. The effect of gravity and the intermolecular forces are neglected. The governing equations have been derived in the lubrication approximation. Nonlinear simulations have been performed for a particular system of liquids, that of fluorinert FC70 and silicone oil 10, formerly used in microgravity experiments. Computations have been made in the region with periodic boundary conditions by means of a finite-difference method. The analysis shows that the heat release/consumption significantly influences the behavior of longwave disturbances. In the case of an oscillatory instability of the quiescent state (by heating from above), the coexistence of the alternating roll patterns, with different orientations and scale (tristability), has been obtained.