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CONVECTIVE OSCILLATORY FLOWS IN TWO-LAYER SYSTEMS UNDER THE ACTION OF AN INCLINED TEMPERATURE GRADIENT

Abstract

Convective phenomena in fluid systems with an interface have been a subject of an extensive investigation at the past few decades. When heating is from below, buoyancy (a volume effect) generates Rayleigh - Benard convection, while thermocapillarity (an interfacial effect) is the origin of Marangoni - Benard convection. The buoyancy effect is more important for relatively thick layers, while the thermocapillary effect plays the dominant role in the case of thin layers or under microgravity conditions. The case where both effects act simultaneously is the most typical. One of the interesting phenomena caused by the joint action of buoyancy and ther- mocapillary effect is the appearance of an oscillatory instability of the mechanical equilibrium. Under experimental conditions it is difficult to guarantee that the temperature gradient is perfectly vertical. The appearance of the horizontal component of the temper- ature gradient changes the situation signicantly: at any small values of the Marangoni number the mechanical equilibrium becomes impossible, and a convective flow takes place in the system. In the present work, the influence of the horizontal component of the temperature gradient on nonlinear oscillatory convective regimes, developed under the joint action of buoyant and thermocapillary effects in the 47v2 silicone oil - water system filling the closed cavity, is investigated. We consider a system of two horizontal layers of immiscible viscous fluids with different physical properties. The system is bounded from above and from below by two isothermal rigid plates kept at constant different temperatures (the system is heated from below). It is assumed that the interfacial tension decreases linearly with an increase of the temperature. To simulate the flows in a closed cavity, we used rigid heat-insulated lateral boundaries. The boundary-value problem was solved by the finite-difference method. It is shown that under the action of the horizontal component of the temperature gradient, specific type of the oscillatory ow - an asymmetric flow, develops in the sys- tem. This type of flow is characterized by the appearance of vortices with a relatively large horizontal size in the layers. It is found that the region of nonlinear asymmetric oscillations exists in a definite interval of the Grashof number values, between the stability regions of a mechanical equilibrium state and a stationary convection.