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OSCILLATORY FLOW AT THE ONSET OF CONVECTION IN TWO-LAYER BÉNARD-MARANGONI SYSTEM

Abstract

Thermal convections in two-layer immiscible fluids confined between parallel plates and heated from below have been studied extensively. In this paper, the time-dependent Bénard-Marangoni convections of two-layer fluid at the onset of convection are investigated experimentally. There were a number of experimental studies on Bénard–Marangoni convection in two-layer liquid systems, but very few successes to observe direct oscillatory at the onset of convection. In our experiment, the flows are visualized from side with particle image velocimetry (PIV) and structure change of velocity fields near onset of convection are observed while the depth ratio varies in a range.

The experiments are conducted in a rectangle cavity, and Fluorinert Electronic liquid FC70 and the silicon oil KF96-10CS are chosen in the two-layer fluid system. The high resolution velocity fields are obtained through processing the particle images with the adaptive and cross correlation method of PIV. In these experiments, the total depth of liquid layer h keeps constant. As the depth ratio hr of two liquid layers varies within a wide range, convective constructions near onset of convection are observed.

Two kinds of onsets of steady convection, mechanically coupled convection and thermally coupled convection, were predicted theoretically and were observed experimentally. Now oscillatory flow at the onset of convection, which is caused by the competition of the flow in the bottom and top layers, is studied directly by velocity field evolution. The kind of convection influenced greatly by the ratio of Rayleigh number of two liquid layer Rar and local Bond number Bo. In our experiment, the variation of the critical temperature difference with the depth ratio shows that the "peak depth ratio" is very far from the "balancing depth ratio"; the oscillatory onsets from stationary were obtained in a big gap of depth ratio in which the "peak depth ratio" located. These results don't agree with the predications of the linear stability analysis. The time sequences of the quasi-standard travel wave at onset of convection were shown clearly. However, we also observed the evolution of the complicate and disorder velocity field induced by the new cells which were born between the main cells and near the interface.