Different instability modes of thermocapillary convection in a two-layer liquid system

Zijing Ding, Qiusheng Liu*

Key Laboratory of Microgravity (National Microgravity Laboratory),

Institute of Mechanics, Chinese Academy of Sciences, Beijing 100190,China,

liu@imech.ac.cn

New instability analysis results of thermocapillary convection in a two-layer system of Silicon oil 10cs and Fluorinert FC70 liquids will be presented. The system of two-layered immiscible liquids is between a rigid plate at bottom and a free upper surface with a passive gas. The system is subjected to a constant temperature gradient $\partial_x T = -b, (b > 0)$ parallel to the interface[1-3], so we defined a Marangoni number $Ma_1 = \gamma_1 b h_2^2 / \rho_2 \nu_2 \kappa_2$, where $\gamma_1 = -\partial_T \sigma$, σ is the surface tension of the liquid-gas interface, $h_2, \rho_2, \nu_2, \kappa_2$ are the depth, density, kinematic viscosity, and heat diffusivity of FC70 respectively. In present study, we consider a micro-gravity environment and neglect the buoyant effect. By using the fully numerical method to study the linear stability problem, two typical cases are studied: (1) steamwise homogenous disturbances (the streamwise disturbance wave number α=0),; and (2) spanwise homogenous disturbances for spanwise disturbance wave number β=0. The theoretical results are shown in Fig.1. When α=0, it is found that convection in the two layers may occur in the form of stationary mode (Mechanical Coupling (MC) mode and Thermal Coupling (TC) mode) or oscillatory mode. And the oscillatory mode takes the form of traveling wave that propagates in either spanwise direction. When β=0, convection in the two layers occurs in the form of oscillatory mode, and this mode takes the form of traveling wave propagating in the same direction as base flow. Furthermore, discussion of the three dimensional disturbances to the system suggests that the spanwise disturbance is the most dangerous mode to the system.

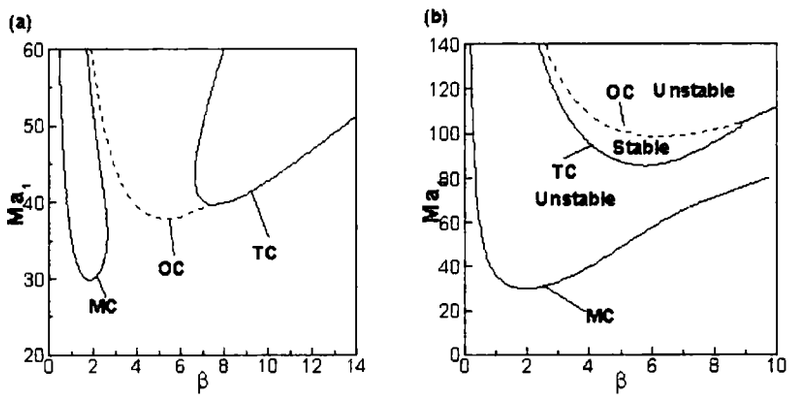

Fig. 1 Marginal curves of the system in *Ma-k* plane for Different Biot numbers:
(a) *Bi*=30 and (b) *Bi*=300, at same depth ratio *h* (h_1/h_2)=0.5, and streamwise disturbance wavenumber α=0. The dashed lines correspond to the oscillation mode and the solid lines represent the stationary mode.

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