Abstract

A stable hydrodynamic system becomes unstable under various external disturbances. The main objective of this dissertation is to discuss in detail the particular conditions for which we get the primary instability at the onset. For this purpose, we have chosen two such systems. (i) Rayleigh-Bérand magneto-convection with temperature modulation and (ii) Faraday instability at the interface of two fluids system with slow rotation. We used Floquet technique to analyze the linear stability of both the systems.

First we consider the modulated magneto-convective Rayleigh–Bénard system. A periodic temperature variation is applied on the lower plate. The oscillatory magneto-convection starts in the system when the Rayleigh number Ra crosses a threshold value Ra_o. The fluid motion at the instability onset may have harmonic or subharmonic oscillation depending on the control parameters. For higher values of Chandrasekhar number Q and at moderate modulation frequency ω, two different instability zones of harmonic oscillation merge to form a single instability zone with two local minima. A new type of bi-critical point was also observed, where two harmonic instability zones with different wave-numbers were excited simultaneously. The variation of critical Ra_o with Chandrasekhar number Q and Prandtl number Pr was also investigated. It can be seen that the dependence of Ra_o on Q and Pr are non-monotonous at higher values of modulation amplitude a. The critical Rayleigh number Ra_o also varies non-monotonically with the modulation frequency ω for moderate value of the modulation amplitude a. The threshold for magneto-convection can be delayed or advanced because of the temperature modulation. The fluid flow at higher values of ω is always harmonic and Ra_o approaches $\mathrm{Ra}_c(a = 0)$ as $\omega \to \infty$.

Next we considered the stability of the interface between two immiscible viscous fluids bounded by two laterally extended plates simultaneously subjected to a sinusoidal gravity modulation and slow rigid-body rotation about the vertical axis, using Floquet technique. The Coriolis force has stabilization effect on the interfacial instability. At larger values of vibration frequency ω_ν, the parametrically excited waves are subharmonic if the amplitude of gravity modulation crosses a threshold value A_c. For thin layers of fluids with low modulation frequency, both subharmonic and harmonic interfacial waves may co-exist at the instability onset. This leads to the possibility of of getting multi-critical points at the onset of interfacial waves, where surface waves with different wave-numbers and are excited simultaneously. The dependence of reduced critical forcing amplitude A_c/G and corresponding wave-number k_c on the relative fluid thickness (d), relative density (ρ) and relative dynamic viscosity (η) were also studied. The threshold always decreases with d, but it increases with ρ and η.

Keywords: Rayleigh-Bénard magneto-convection, Temperature modulation, Faraday instability, Interfacial Instability, Floquet Analysis