Rayleigh-Bénard convecton in confined systems

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Abstract

Rayleigh-Bénard convection (RBC), natural convection induced by unstable vertical temperature gradient in a fluid layer, has been investigated as one of typical research platforms for flow transition and turbulence studies. The phenomenon is governed by Rayleigh number, Prandtl number, and size/shape of the fluid layer, and variety of flow regiems exhibits depending on them. Adding an extra confinement to the system induces further diverseness on the phenomenon which would represent global fluid motions in nature. In the present talk, I will introduce RBC with two different confinements on the convection by a horizontal magnetic field and a Hele-Shaw system. These are simplest models for molten earth's core and fluid motion in fractures. Both RBCs exhibit typical two-dimensional oscillatory motions of convection rolls, which cannot be descrived by classical theories. In the the former system, sufficiently strong magnetic field stabilizes the convective motion into two-dimensional in the directin of magnetic field by Joule dissipation despite large Rayleigh numbers that can induce thermal turbulence. But sufficiently large inertia modifies convection rolls and induces unsteady motion on these (Fig. 1(a)). In the latter system, strong lateral confinement restricts convective motion into two-dimensional even at large Rayleigh numbers (Fig. 1(b)). There is neglibgible inertia contribution on the phenomena, but large temperature gradient around corners induces unsteadiness on corner rolls with keeping central elongated convection rolls steady. Details of the physics behind the phenomena are explained in the talk.

Keywords: Rayleigh-Bénard convection, flow transition, magnetic field, lateral confinement

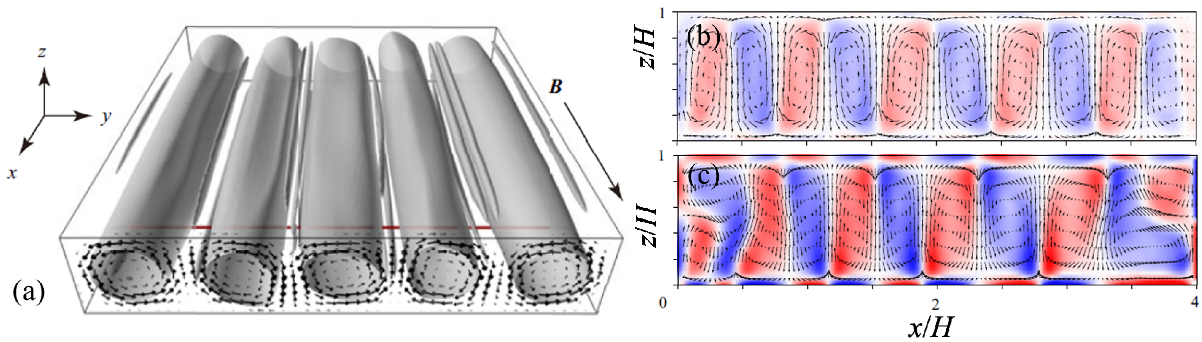

Figure 1. (a) "Deformed" convection rolls aligned in the direction of horizontal magnetic field[1]; (b)(c)vertically elongated convection rolls in a laterally confined fluid layers, where oscillatory corner rolls emerge in (c) in addition to steady rolls [2]

[1] Y. Tasaka, T. Yanagisawa, K. Fujita, T. Miyagoshi, and A. Sakuraba, "Two-dimensional oscillation of convection rolls in a finite liquid metal layer under a horizontal magnetic field" J. Fluid Mech. 911 (2021) A19
[2] T. Yanagisawa, S. Takano, D. Noto, M. Kameyama, Y. Tasaka† "Quasi-steady transition in confined convection" J. Fluid Mech. 1000 (2024) A44

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