On solitary vortices near the convection threshold in ferrocolloid

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Experimental studies and numerical simulations of stability of buoyancy-driven flows in a ferrocolloid for the cases of horizontal and inclined vertical orientation of a thin cylindrical cavity are performed. The ferrocolloid contains single domain magnetite particles suspended in kerosene carrier liquid and has the susceptibility thousand times higher then natural media. The influence of a homogeneous longitudinal magnetic field on convective instability and spatio-temporal patterns was also investigated. The results prove that a uniform longitudinal magnetic field allows to control the stability and the shape of secondary convection motions at inclined orientation of layer. The spirals, localized states and other travelling wave regimes were revealed.

In the case of ferrocolloids the gradients of magnetic permeability may arise due to both temperature and particle concentration gradients. The particle mass flux in a classical form is summarized from the translation diffusion coefficient and the thermal diffusion ratio. However, the explanation for the observed self-oscillation regimes in magnetic fluid for the cavities of sufficiently large thickness (several to tens of millimeters) is conditioned by the competition of density variations originating from the fluid thermal expansion and barometric sedimentation. So at the terrestrial conditions the heat and mass transfer is essentially complicated because of the uncontrollable gravitational sedimentation of magnetic particles and their aggregates.

As known, thermally driven shear flow in an inclined layer draws up convection rolls in the direction of inclination. In a ferrocolloid the repeated transients involving localized roll convection and pure shear flow took place. Under action of uniform longitudinal magnetic field orientated perpendicular to flux velocity of shear motion on such long-wave transients can lead to complicated types of chaotic localized states or solitary vortices.

Visualization of convection patterns was provided by means of liquid crystal sheet. The temperature oscillations were registered using thermocouples. Temporal evolution of the oscillations was analyzed using wavelets. The frequencies of temperature oscillations obtained under wavelet analysis were compared with results of Fourier analysis and visual observations with the help of video camera. Two main types of frequencies corresponding to multi-hour and minute periods were registered. They account for fast or slow (global) changes of patterns. To study the effect of sedimentation of large aggregates on convective instabilities, numerical simulations using both single phase assumption and two-phase mixture model were carried out for the same setup.

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