Flow pattern transitions in vibration induced convection in low gravity

Valentina Shevtsova*, Aliaksandr Mialdun, Denis Melnikov, Yuri Gaponenko, Jean Claude Legros

Microgravity Research Centre, Universite Libre de Bruxelles, CP 165/62, Avenue F.D. Roosevelt 50, B-1050, Brussels, Belgium
E-mail of corresponding person: vshev@ulb.ac.be

ABSTRACT

Vibrational convection refers to the specific flows that appear when a fluid with density gradient is subjected to external vibration. The density gradient may result from the inhomogeneity of temperature or composition. High frequency vibration leads to the appearance of time-averaged (mean) flows or streaming flows.

Vibrations can suppress or intensify gravitational convection depending on the mutual orientation of vibration axis and thermal or compositional gradient. Vibrational convection is an additional way of transporting heat and matter in weightlessness similar to thermo-and solutocapillary convection. Similar to gravitational convection, the vibrational convective mechanisms (mean flows) is characterized by the dimensionless parameter which is vibrational analogue of Rayleigh number; we call it as Gershuni number.

In a rectangular cavity under weightlessness, a non-zero mean flow exists at any value of the Gershuni number Gs when the direction of vibration is perpendicular to the temperature gradient (this configuration is considered in the present study). For small values of the Gershuni number, the stationary mean flow is weak and has a four-vortex symmetrical structure. Such ‘quadruple’ flows were previously observed in numerical simulations. When the Gershuni number exceeds some critical value Gs(*cr)* , a flow pattern bifurcates to the pattern with different symmetry: one large diagonal vortex and two small vortices in the corners. The critical value of the Gershuni number depends on the physical properties of the fluid and boundary conditions.

Mentioned above convective flows and transition between patterns were studied in low gravity during parabolic flight experiments [1,2] and in zero gravity conditions (experiment IVIDIL on the ISS). Quadruple flows for the first time were observed experimentally. The attention will be focused on the presentation of the experimental results and its direct numerical simulations.

REFERENCES

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