INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

Rayleigh-Bénard convection (RBC) is one of the classical problems in fluid dynamics, in which a fluid layer is heated from below and cooled from the top. In this thesis, various aspects of turbulent RBC inside a Cartesian box and cylindrical cell are studied, using direct numerical simulations (DNS). Our prime focus is to identify and characterize large-scale circulation (LSC), which is an organization of thermal plumes to form a large-scale coherent structure. For rotating RBC inside a cylindrical container, we identify different flow regimes based on the Fourier modes and flow structures. At low rotation rates, LSC is observed, while at higher rotation rates, wall-bounded flow structures, namely quadrupolar and sextupolar are obtained. The reorientations of LSC are identified as rotation-led and cessation-led based on their nature of occurrence, and as partial and complete reversal depending on the azimuthal drift. In addition to the previously reported rare events like cessations and double-cessations, an interesting event of multiple-cessation is observed in the present study. For turbulent RBC inside a cubic cell, we have been able to attain a high Rayleigh number (Ra) range, up to $Ra = 10^9$, and study various characteristics of the flow, especially thermal plumes and LSC. We observe that the volume fraction of the plume decreases, while that of the turbulent background increases with Ra. Comparisons with the theoretical predictions show that the dissipation from the plume region follows the Grossmann-Lohse scaling, while considerable deviations are observed in the background contribution. By comprehensive analysis of the flow behaviour in different planes, a mechanism of flow reversals is proposed. Our analyses show that the corner-rolls present in the plane containing LSC play a key role in destabilizing the LSC, and thus, resulting in reversals. We notice that partial reversals are a common occurrence across all Ra, while complete reversals are rare occurrences and restricted to low Ra. The evaluation of turbulent kinetic energy (TKE) budget across the LSC and non-LSC planes indicate that the production of TKE occurs at localized pockets in both the planes, while dissipation of TKE largely happens near the plane containing LSC.