Wall-bounded thermal turbulent convection driven by heat-releasing point particles

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In this work we study the convection turbulence which is driven by heat-releasing point particles. The point particles absorb energy at constant rate from the external environment and then heat the surrounding fluid and induce the flow motions. Such system is highly related to various particle-laden engineering flows such as the particle based solar receivers [1]. Three-dimensional direct numerical simulations are conducted for a fluid layer bounded from top and bottom by two parallel plates. We focus on the effects of varying Rayleigh number and Stokes number, while the other parameters are fixed.

A parameter regime is identified where all the particles gradually accumulate near the top boundary, which breaks the simulation. By the scaling analyses of the time scales for particles penetrating and being trapped by the top boundary layer, theoretical predictions can be made for the boundaries of parameter regime, which agree with the numerical results. Then by using the global balance between the viscous dissipation rate and convective flux, the relations between the power-law scalings for different quantities can be understood. The preferential concentration of particles are also investigated by using the Voronoï diagram and the radial distribution functions. Preferential concentrations are found at a wide range of length scales for intermediate Stokes numbers.

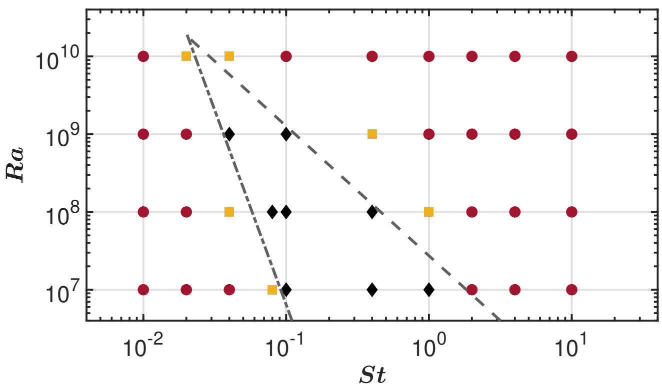

Figure 1: The phase space explored by the current study. In the cases marked by the black diamonds, all the particles gradually accumulate near the top plate and the simulations break down. All other cases can reach a statistically steady state. In the cases marked by orange squares the normalized number density is larger than 10 near the top plate. The two dashed lines mark the theoretical predictions for the transition boundaries between different regimes. The figure is adopted from Du and Yang (*J. Fluid Mech.*, **953**, A41, 2022).

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[1] Pouransari and Mani, *J. Sol. Energy Engng.*, **139**, 021008 (2017)