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CONFINED REGIMES IN RAYLEIGH-BÉNARD CONVECTION USING REDUCED DIMENSIONALITY MODELS

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We consider Rayleigh-Bénard convection inside slim rectangular cells of transversal aspect ratio Γ . Previous works [1, 2] show a change of regime as the depth becomes comparable to the size of thermal plumes, going from an unconfined regime, to a plume-controlled regime and to a confined regime (III). For the latter, we developed a reduced model, which improves the Hele-Shaw approximation by taking into account inertial corrections along the lines of [3]. This model is shown to be in good agreement with 3D DNS results, for instance we compared global quantities such as the Reynolds and Nusselt numbers, as well as the various boundary layer thicknesses. We take advantage of the lower computational cost of the model to perform a parametric study for different (Ra, Pr) in the range $1/256 < \Gamma < 1/32$. In the parameter space $Ra - \Gamma$, we identify inside the confined regime reported by [1, 2] a transition to a new regime denoted by IV (see figure 1) with larger scaling exponents for the Nusselt and Reynolds numbers. This transition is related to changes in flow structures as well as in the relative thicknesses of thermal and viscous boundary layers.

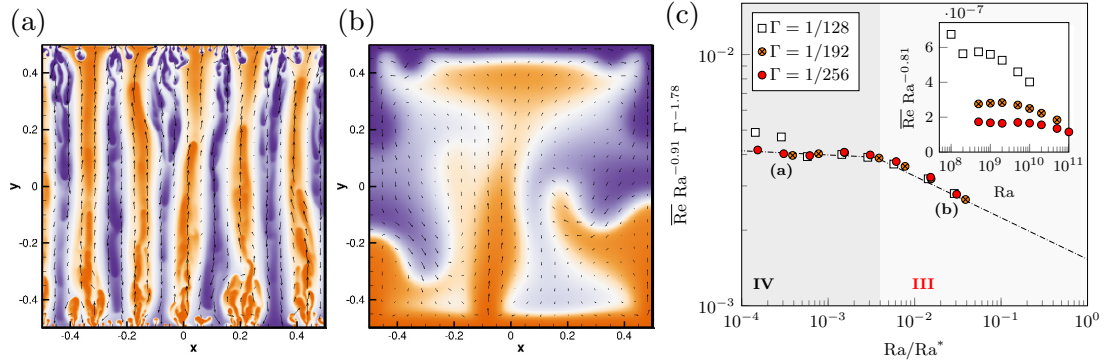


Figure 1: Reduced model for $Pr = 4.38$. Fig. (a,b) Snapshot of the temperature field for $\Gamma = 1/256$. (a) inside the confined regime (III) for $Ra/Ra^* = 3 \cdot 10^{-2}$, where Ra/Ra^* is a confinement parameter defined in [2]. (b) inside the new regime (IV) for $Ra/Ra^* = 2 \cdot 10^{-4}$. (c) compensated Reynolds number as a function of Ra/Ra^* .

References

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