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► **To cite this version:**

Mebarek Belkadi, Anne Sergent, Berengere Podvin, Yann Fraigneau. HEAT TRANSFERT AT THE ROUGHNESS SCALE IN TURBULENT RAYLEIGH-BÉNARD CONVECTION. 17TH EUROPEAN TURBULENCE CONFERENCE,, Euromech, Sep 2019, Torino, Italy. hal-04390710

**HAL Id: hal-04390710**

**<https://hal.science/hal-04390710>**

Submitted on 12 Jan 2024

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## HEAT TRANSFERT AT THE ROUGHNESS SCALE IN TURBULENT RAYLEIGH-BÉNARD CONVECTION

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Turbulent convection is a spontaneous physical process present in many natural systems as well as in engineering applications. However most of these systems are non-ideal in terms of underlying surfaces involving specific topography or small-scale roughness. Moreover interactions between buoyant flow and plate roughness result in a global heat transfer enhancement and in some cases, in an increase of the heat transfer scaling exponent (see for ex. [2]). In this study, we consider thermal convection over a regularly roughened plate in a Rayleigh Bénard cell. The objective is to clarify interactions between the large scale circulation filling the box and the flow around the roughness elements by means of direct numerical simulations. Three successive heat transfer regimes are investigated from inactive roughness to a regime where the heat transfer relative increase is larger than the relative surface increase induced by roughness addition.

The simulations are performed in a box-shaped cell of aspect ratio (depth over cell height) equal to 1/2 with water as working fluid for a Rayleigh number  $Ra$  ranging from  $5 \times 10^5$  to  $5 \times 10^9$ . The roughness is introduced on the bottom plate by a set of square based obstacles regularly spaced, modelled by using an immersed boundary method, while the top plate is kept smooth.

Results are validated against experimental and numerical data from literature. As expected, it exhibits an enhancement of heat transfer measured by the Nusselt number  $Nu$ , depending on the relative sizes of the mean boundary-layers and the obstacle height in agreement with previous studies from the literature [3, 1, 4]. Then, we investigate the different heat transport mechanisms at the roughness scale for three successive regimes (fig. 1). Our study reveals that the change of heat transport regime is mainly governed by physical features of fluid zone surrounding the obstacles. Flow dynamics and boundary layer structure near rough surface are also reported.

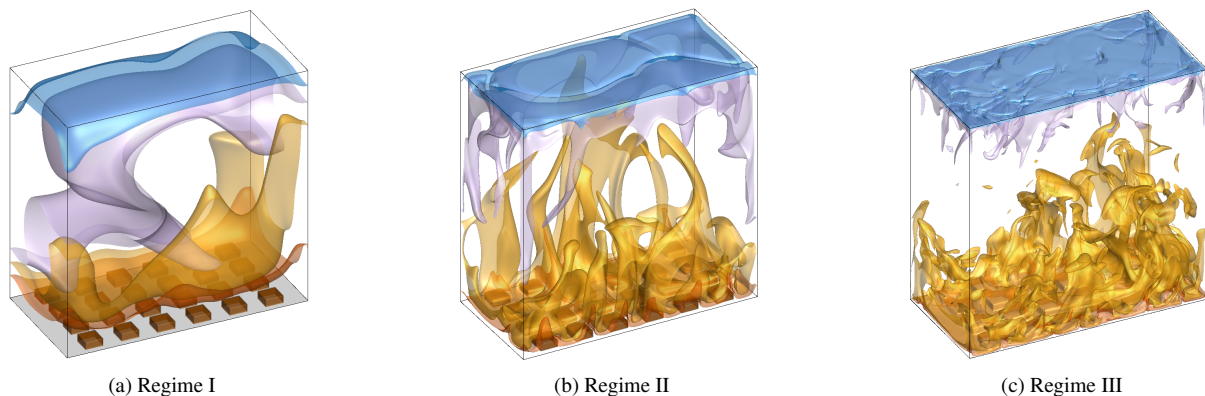


Figure 1: Instantaneous temperature fields obtained for (a)  $Ra = 10^6$ , (b)  $Ra = 5 \times 10^7$  and (c)  $Ra = 10^9$ . Isosurfaces correspond to  $\theta = (0.2, 0.45, 0.65, 0.8)$ .

### References

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