Influence of roughness on turbulent thermal convection

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Rayleigh-Benard convection is a well-studied model system for natural convection. It consists in an infinite layer of fluid between two isothermal and horizontal boundaries: a hot on the bottom and a cold one on the top, where thermal and viscous boundary layers can develop. It has been studied for more than a century now, but it remains poorly understood in the turbulent case. In the laboratory, it is investigated using Rayleigh-Benard cells, where the horizontal boundaries are plates, and where the fluid is contained inside a tank with adiabatic side walls. For the last decades, several experiments, conducted in cryogenic helium or pressurized SF6 gas, have exhibited thermal behavior compatible with the 'Ultimate regime' predicted by Kraichnan in 1962. But the origin of this transition is still an open debate. The system seems to be extremely sensitive to boundary conditions. In order to investigate it, several expriments involving controlled roughness on those plates, have been recently performed, for example [1] or [2]. Those roughness are chosen to artificially disrupt the boundary layers. It has been observed, that a modification of the thermal behavior of the system occurs when the height of the thermal boundary reaches the height of the roughness.
In this presentation, we propose a comparison between different height of roughness. We, also, demonstrate that the height of the roughness is a characteristic length which control the thermal behavior of the cell and not just the initial transition, see figure 1. In this figure is shown the thermal transfer in the presence of square roughness, as a function of the Rayleigh number ($Ra = (\alpha \Delta T g H^3)/(\nu\kappa)$, where H is the height of the cell and ΔT the difference of temperature between the plates.). This quantity characterises the temperature forcing, here, it is normalised by the height of the roughness h_0. The collapse is good. We also underlines the existence of a saturation at high Rayleigh number.

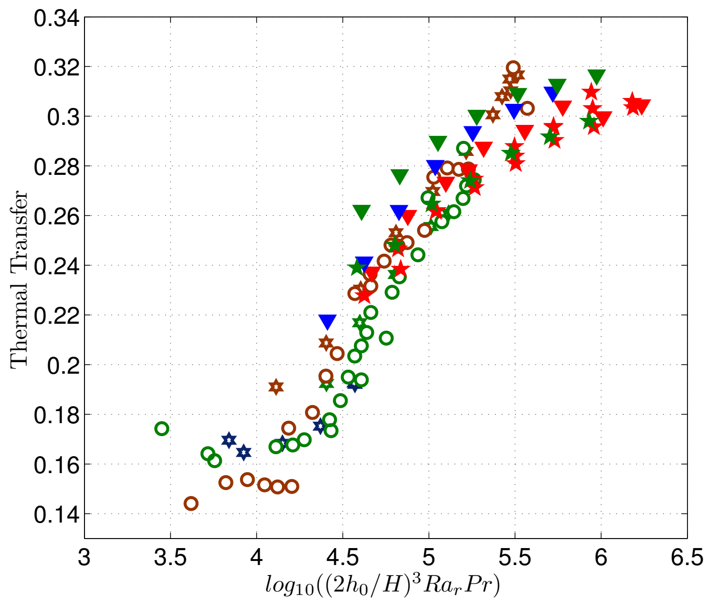

Figure 1: Thermal transfer as a function of the Rayleigh number normalised by the height of the roughness

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