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Scaling Laws for Thermal Convections

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We begin with the derivation of various scaling laws for Rayleigh–Bénard convection using a combination of dimensional considerations and phenomenological models in the spirit of Castaing et al(J. Fluid Mech., 1989). Other than being simple, these models also offer an intuitive understanding of the connection between certain flow behaviours and the corresponding scaling laws. Castaing et al only applied their model to obtain the $Nu \sim Ra^{2/7}$ scaling. We show that this model, with some minor changes, can also produce other scalings which have been derived using more sophisticated methods and measured recently in experiments. Similar techniques are then applied to the analysis of heat transfer in an enclosure with an inlet and an outlet for cooling air flow. The results are summarised in a regime diagram delineating different types of convection and correlation scaling. The similarities between these with heat transfers from a flat plate will be highlighted. It will be thus shown that the method can be applied to both internal (e.g. in a sealed or unsealed box) and external (e.g a flat plate) flows.

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