Heat Transport Scaling in Rayleigh–Bénard Convection: From Deterministic Bounds to Stochastic Models

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Abstract

I will discuss quantitative results on heat transport in Rayleigh–Bénard convection obtained via rigorous analysis. In particular, I will review refined versions of the background method of Doering and Constantin, which simplify the structure of the argument and lead to improved upper bounds on the Nusselt number Nu as a function of the Rayleigh number Ra under various boundary conditions and geometries, including flat and rough domains. I will then present new work motivated by stochastic parameterizations of turbulent transport. We consider Rayleigh–Bénard convection in an infinite half-space in the infinite Prandtl number limit, and model small-scale velocity fluctuations by introducing stochasticity directly at the level of the advecting velocity field. Under natural structural assumptions on this stochastic velocity model, we recover the classical Malkus scaling in three dimensions. Moreover, the framework is flexible and allows different scaling exponents to emerge under alternative parameterization choices, thereby clarifying how statistical assumptions on the velocity field determine macroscopic heat transport laws.

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