Rolls, Runaway Modes and Energetic Consistency in Spectral Truncations of the Rayleigh Bénard Problem

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Abstract

The Rayleigh Bénard convection problem from fluid dynamics is well-known for its rich dynamics, nonlinear waves and roll state spatial patterns. In this talk we present here our recent results on the issue of energetic consistency in Fourier-Galerkin truncations of this problem [1, 2]. We give mode selection criteria which are necessary and sufficient for a truncated model to satisfy the potential energy balance associated with the PDE. We prove also that the potential energy balance is sufficient for the truncated system to admit a compact attractor, and that there exist unbounded trajectories (so called "runaway modes") in a large class of energetically inconsistent models. Finally, we examine the cascade of bifurcations of roll states, their stability and their heat transport via a hierarchy of energetic consistent models.

References

[1] Roland Welter (2025) *Rotating Rayleigh–Bénard Convection: Attractors, Bifurcations, and Heat Transport via a Galerkin Hierarchy*, SIAM Journal on Applied Dynamical Systems, Vol. 24

[2] Jens D.M. Rademacher and Roland Welter (2026) *Energetic consistency and heat transport in Fourier-Galerkin truncations of free slip 3D rotating convection*, arXiv preprint: *https://arxiv.org/abs/2505.07678*