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Direct Statistical Simulations of a Rotating Thermal Annulus

JEFFREY OISHI, Bates College, STEVEN TOBIAS, University of Leeds, BRAD MARSTON, Brown University, KEATON BURNS, Massachusetts Institute of Technology — Turbulent systems generate and interact with mean flows in a wide variety of natural systems. Understanding the nature of these interactions, particularly for systems far from equilibrium, remains a paramount priority in understanding large-scale flows on planets and stars. The fundamental problem in studying such systems via direct numerical simulation (DNS) is the fact that the smallest scales can have a significant impact on the mean flows, even when they are very widely separated. One way to make progress is to study the statistics of the flow rather than detailed flow variables themselves. By expanding around the mean flow in terms of equal-time cumulants, we can arrive at a closed set of equations of motion for the cumulants. Here, we present results using an expansion terminated at the second cumulant (CE2) for rapidly rotating thermal convection in an annulus. CE2 discards eddy-eddy interactions that yield eddies; it is fundamentally quasi-linear. We focus on a particular case in which the direct numerical simulation yields an initial three-jet solution that is unstable to a two-jet solution. Interestingly, CE2 predicts a stable three-jet solution, though we find that by biasing the initial conditions to favor certain symmetries, CE2 reproduces the DNS results.

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