Suppressing Wall Modes in Rotating Rayleigh-Bénard Convection

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Abstract

Rotating convection pervades natural systems, from planetary interiors to atmospheric dynamics. A classical model for this phenomenon is the rotating Rayleigh-Bénard convection (RRBC) setup. Studies in confined RRBC revealed a striking phenomenon: the strongest vertical velocities occur near the side walls in precessing wavelike structures called wall modes (WM). Such modes endure into highly turbulent states, biasing heat transport and contaminating bulk dynamics via radial jets, preventing the system from organizing. Suppressing WM is therefore of great interest. Numerical work suggests that horizontal sidewall barriers could achieve this. We experimentally and numerically test this strategy in cylindrical cells equipped with ring-shaped barriers in the sidewall. Our results demonstrate control of WM fingerprints, suppressing strong near-wall vertical velocities, jet ejections into the bulk and regulating their contribution to the global heat flux. Intriguingly, a secondary azimuthal flow layer forms next to the faces of the barriers, exhibiting a less intrusive response than the WM; we can both explain its formation and explore strategies to mitigate it. Sidewall barriers thus enable control of WM in RRBC, though the induced secondary flows must be considered in practical applications.

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