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Observations of Instabilities in Stratified Taylor-Couette Flow[1]
BRUCE RODENBORN, Centre College, RUY IBANEZ, Baylor University, HARRY L. SWINNEY, Center for Nonlinear Dynamics and Department of Physics, University of Texas at Austin — Inviscid analyses by Molemaker et al. (Phys. Rev. Lett. 86, 5270, 2001) and by Dubrulle et al. (Astron. Astrophys. 29, 1, 2005) predicted that a fluid with a vertically varying density will be less stable than a uniform fluid when the fluid is contained inside a concentric rotating cylinder system and subject to anticyclonic shear. Dubrulle et al. named this instability the stratorotational instability and a subsequent viscous theory by Shalybkov and Rudiger (Astron. Astrophys. 438, 411, 2005) hypothesized that such stratified flow is stable when the ratio of outer and inner cylinder rotation rates μ is less than the ratio of the inner and outer cylinder radii η. Le Bars and Le Gal (Phys. Rev. Lett. 99, 064502, 2007) confirmed this hypothesis in experiments for $Re < 1200$ with $Re \equiv (r_o - r_i)\Omega_i r_i/\nu$. However, we find the SRI exists for $\mu > \eta$ when the density gradient is large. We also find that the axial wavelength scales linearly with the internal Froude number and that the onset of the SRI is suppressed for $Re > 4000$, a region previously unexplored in experiments. For $Re > 8000$, we find that the fluid does not exhibit the SRI but transitions to a spatially nonperiodic state that mixes the fluid.

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