Wave and vortex regime in large-gap stratified Taylor–Couette flow

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Abstract

Stratified Taylor–Couette (TC) flows have been investigated to understand, among others, the equatorial ocean circulation [1,2,3], mixing by vortices [4,5], and in an astrophysical context the stability of accretion disk due to the so-called strato-rotational instability observed experimentally in [6] and first compared to theory in [7]. Here, a centrifugally unstable flow is generated by a cylinder of radius R that is impulsively set into rotation about its vertical axis with angular speed Ω. The gap width is 3 to 13 times larger than the radius of the inner cylinder, and is filled with a linearly stratified fluid with buoyancy frequency N. We are considering the thin vorticity layer at the cylinder boundary of which the dynamics are determined by the Froude number $F = /N$ and the Reynolds number $Re = \Omega R^2/\nu$, with ν the viscosity. A bifurcation is found at $F = 1$, with for $F > 1$ centrifugally unstable flow with vortices intruding in the ambient stratification, and for $F < 1$, helicoidal inertial waves propagating along the inner cylinder boundary. This bifurcation has also been found in the small gap TC flow in [3,8] though here the waves are unstable and increase in amplitude when the Reynolds number $Re_n = \Omega R^2/(n\nu) > 130$, with n the azimuthal wave mode, and dissipate for $Re_n < 130$. The origin of the instability is discussed.

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