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Nonlinear dynamics in eccentric Taylor–Couette–Poiseuille flow

BENOÎT PIER, LMFA, CNRS-Université de Lyon, C. P. CAULFIELD, BP Institute & DAMTP, University of Cambridge — The flow in the gap between two parallel but eccentric cylinders and driven by an axial pressure gradient and inner cylinder rotation is characterized by two geometrical parameters (radius ratio and eccentricity) and two dynamic parameters (axial and azimuthal Reynolds numbers). Such a theoretical configuration is a model for the flow between drill string and wellbore in the hydrocarbon drilling industry. The linear convective and absolute instability properties have been systematically derived in a recent study [Leclercq, Pier & Scott, *J. Fluid Mech.* 2013 and 2014]. Here we address the nonlinear dynamics resulting after saturation of exponentially growing small-amplitude perturbations. By using direct numerical simulations, a range of finite-amplitude states are found and characterized: nonlinear traveling waves (an eccentric counterpart of Taylor vortices, associated with constant hydrodynamic loading on the inner cylinder), modulated nonlinear waves (with time-periodic torque and flow rate) and more irregular states. In the nonlinear regime, the hydrodynamic forces are found to depart significantly from those prevailing for the base flow, even in situations of weak linear instability.

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