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Nonlinear equilibrium states in viscoelastic Taylor-Couette flow

LAURA NICOLAOU, JACOB PAGE, Imperial College London, TAMER ZAKI, Johns Hopkins University — Viscoelastic Taylor-Couette flow exhibits a variety of instabilities, some of which can arise in the absence of inertia altogether. Nonlinear solutions of the equilibrium states are sought, where the distorted mean flow is unchanged and the finite-amplitude instability waves are saturated. A key assumption in the theory is that nonlinearity is restricted to the action of the perturbations on the mean flow. Therefore, the perturbation shape is preserved throughout its growth and saturation, and is specified as a weighted sum of the unstable, linear eigenmodes. At low elasticity, a single unstable mode exists in the form of a stationary Taylor vortex, and the predicted saturated state compares favourably with direct numerical simulation (DNS). DNS reveals that the higher harmonics are an order of magnitude weaker than the fundamental frequency, which substantiates the assumption adopted in the theory. At moderate elasticity, multiple modes become unstable, including axially-travelling elastic rolls and stationary vortices. Equilibrium solutions built from superpositions of these modes explain observations from experiments in the literature over a range of shear rates.

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