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Resolvent analysis-based models of nonlinear Taylor vortex flow[1]

BENEDIKT BARTHEL, California Institute of Technology, XIAOJUE ZHU, Center of Mathematical Sciences and Applications, and School of Engineering and Applied Sciences, Harvard University, BEVERLEY MCKEON, California Institute of Technology — Taylor vortices have recently garnered renewed attention as an analogue for the self-sustaining process (SSP) in wall bounded shear flows. An instability of the mean flow leads to streamwise rolls which form streaks, which in turn become unstable and feedback to the rolls. We seek to shed light on the SSP by first understanding the dominant nonlinear interactions which sustain Taylor vortices. Here we use the resolvent formulation of McKeon and Sharma to treat the nonlinearity not as an inherent part of the governing equations but rather as a triadic constraint which must be satisfied by the model solution. We exploit the low rank linear dynamics of the system to calculate an efficient basis for our solution, the coefficients of which are then calculated through an optimization problem where the cost function to be minimized is the triadic consistency of the solution with itself as well as with the input mean flow. We compare our results to DNS of Taylor Couette flow for a range of Reynolds numbers (Zhu et al., Comp. Phys. Comm., 2018). Our model solution replicates both the flow structures as well as the turbulent statistics observed in the simulations.

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