Abstract Submitted
for the DFD20 Meeting of
The American Physical Society

From linear stability to self-sustaining solutions: Taylor vortex flow through the lens of resolvent analysis[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 are known to arise due to a centrifugally driven, supercritical instability of the laminar base flow. However, as the Reynolds number increases past the critical value, the Taylor vortices are no longer driven by centrifugal mechanisms, but are instead driven by nonlinear interactions reminiscent of a self-sustaining process and thus persist well beyond the onset of turbulence (Sacco et al., JFM, 2019). Here we use the resolvent formulation of McKeon and Sharma to model this transition from linear instability to nonlinear Taylor vortices. Near the critical Reynolds number, we show that the Reynolds stress is accurately modeled by the self-interaction of a single eigenmode of the unstable base flow, highlighting the linear amplification mechanisms at play, and circumventing the reliance on an a priori known mean profile. We then efficiently and accurately model the fully nonlinear Taylor vortex flow by treating 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. These results could allow for a systematic algorithm to bootstrap solutions up in Reynolds number starting from the bifurcation from the laminar state well into the nonlinear regime.

[1]ONR Grant: N00014-17-1-2307 and N00014-17-1-3022

Benedikt Barthel
Caltech

Date submitted: 31 Jul 2020 Electronic form version 1.4