Abstract Submitted
for the DFD20 Meeting of
The American Physical Society

Viscosity-Stratified Nonlinear Optimal Perturbation and its Evolution in a 3D Channel[1] RITABRATA THAKUR, International Centre for Theoretical Sciences - TIFR, ARJUN SHARMA, Cornell University, RAMA GOVINDARAJAN, International Centre for Theoretical Sciences - TIFR — We show that the early stages of nonlinear optimal perturbation growth in a viscosity-stratified flow are different from those in a constant-viscosity flow. We use a numerical technique of direct-adjoint looping and nonlinear optimisation to obtain the nonlinear optimal perturbation which maximises the time-intgrated perturbation kinetic energy of the system. The geometry of flow is a 3-dimensional channel. The two walls of the channel are kept at different temperatures and the viscosity varies as an exponential function of temperature. The Orr and modified lift-up mechanisms are in operation at low (linear) and high (nonlinear) perturbation amplitudes, respectively, at our subcritical Reynolds number of 500 and Prandtl number 7. The nonlinear optimal perturbation contains more energy on the hot (less-viscous) side, with a stronger initial lift-up. However, as the flow evolves, the important dynamics shifts to the cold (more-viscous) side, where wide high-speed streaks of low viscosity grow and persist. This strengthens the inflectional quality of the velocity profile. We show why the linear optimal misses this physics by describing the mechanism behind this energy growth. The Prandtl number does not qualitatively change the findings with the current viscosity model.

[1]12-RD-TFR-5.10-1100 of the Department of Atomic Energy and the Ocean Mixing and Monsoon program of the Ministry of Earth Sciences, India

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Date submitted: 01 Aug 2020 Electronic form version 1.4