Abstract Submitted
for the DFD19 Meeting of
The American Physical Society

A Well-Conditioned Numerical Method for Resolvent Analysis of Viscoelastic Channel Flows[1] GOKUL HARIHARAN, Department of Chemical Engineering and Materials Science, University of Minnesota, MIHAILO JOVANOVIC, Ming Hsieh Department of Electrical and Computer Engineering, University of Southern California, SATISH KUMAR, Department of Chemical Engineering and Materials Science, University of Minnesota — Linear analyses provide useful information about the potential for transition to nonlinear states. While a modal approach furnishes information about long-time growth or decay of initial conditions, non-modal approaches give insight into the amplification of disturbances in a linearly stable flow. Here, we conduct non-modal analysis of inertialess 2D viscoelastic channel flows. Our analysis reveals large stress gradients in the near-wall region (for plane Poiseuille flow) and in the channel center (for plane Couette flow). These steep stress gradients can only be resolved using recently developed well-conditioned spectral methods, e.g., the ultraspherical and spectral integration methods. Furthermore, even if the discretization method is well-conditioned, computation of frequency-responses can be erroneous if singular values are obtained as the eigenvalues of a cascade connection of the resolvent operator with its adjoint. We address this issue by introducing a feedback interconnected system that avoids matrix inverses and allows reliable frequency-response calculations of viscoelastic channel flows at high Weissenberg numbers (∼500). The steep stress gradients that we identify may play a role in explaining recent experiments concerning transition to elastic turbulence.

[1]National Science Foundation

Satish Kumar
University of Minnesota

Date submitted: 25 Jul 2019 Electronic form version 1.4