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Elastic effects on the shear flow instabilities in viscoelastic fluids

AHMED KAFFEL, Department of Mathematics Virginia Tech, DEPARTMENT OF MATHEMATICS VIRGINIA TECH TEAM, DEPARTMENT OF MATHEMATICS TEAM — A linear stability analysis was applied and the stability equation is derived and solved numerically using the spectral Chebyshev collocation method. The objective is to study the elastic effects on the instability of inviscid parallel shear flows. We focus on the upper convected Maxwell model in the limit of infinite Weissenberg and Reynolds numbers. Specifically, we study the effects of elasticity on the instability of a few classes of simple parallel flows, specifically plane Poiseuille and Couette flows, the hyperbolic-tangent shear layer and the Bickley jet. The algorithm is computationally efficient and accurate in reproducing the discrete eigenvalues. We consider flows bounded by walls as well as flows bounded by free surfaces. In the inviscid, nonelastic case all the flows we study are unstable for free surfaces. In the case of wall bounded flow, there are instabilities in the shear layer and Bickley jet flows. In all cases, the effect of elasticity is to reduce and ultimately suppress the inviscid instability. The numerical solutions are compared with the analysis of the long wave limit and excellent agreement is shown. We found flows which are long wave stable, but nevertheless unstable to wave numbers in a certain finite range. While elasticity is ultimately stabilizing, this effect is not monotone; there are instances where a small amount of elasticity actually destabilizes the flow.

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