Center for Environmental & Applied Fluid Mechanics

"Viscoelastic Channel Flows: Turbulence without Inertia?"

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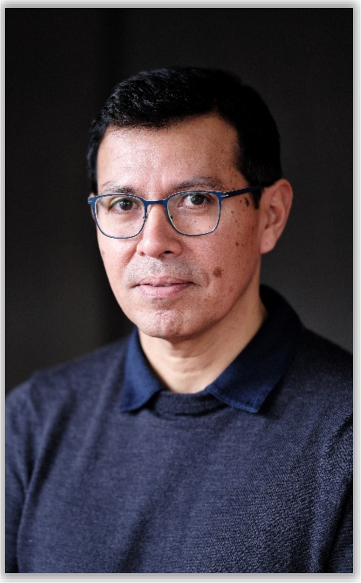
Mechanical Engineering & Applied Mechanics



Viscoelastic fluids do not flow like water does. One of the most striking differences is the presence of hydrodynamic instabilities in these fluids (e.g., polymeric or surfactant solutions) even in the absence of inertia. At high flow rates, flows of viscoelastic fluids exhibit a completely new type of chaotic behavior – *purely elastic turbulence* – that has no analogues in Newtonian fluids like water. The precise mechanism of purely elastic instabilities is still not well understood, even though it is fundamental for our knowledge of how complex materials and biological fluids flow, chemical and petroleum industries.

It is a common assumption that, in the absence of inertia, the flow of a viscoelastic fluid in pipes and channels is linearly stable to flow perturbations. Recent evidence, however, suggests that such flow may be unstable to finite amplitude perturbation. This type of instability is akin to the transition from laminar to turbulent flows in ordinary Newtonian fluids where the control parameter is the Reynolds number (*Re*). Here, on the hand, the control parameter is the Weissenberg number (*Wi*).

In this talk, we present evidence of a subcritical nonlinear instability for the flow of a dilute polymeric solution in a parallel channel flow using a microfluidic device. The flow is investigated using dye advection, particle tracking velocimetry, and pressure sensors. Results show sustained velocity fluctuations far downstream away from the initial perturbation for strong enough disturbances; small disturbances decay quickly under the same flow conditions. A hysteresis loop, characteristic of subcritical instabilities, is observed. The flow is characterized by non-periodic velocity fluctuation showing common signatures of elastic turbulence. Pressure measurements show rapid increase in drag as *Wi* is increased followed by and a turbulent-like regime characterized by a sudden decrease in drag and a weak dependence on *Wi*. Finally, we explore the mechanisms for these instabilities using 3D particle tracking.

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Johns Hopkins Whiting School of Engineering