Turbulent viscoelastic mixing layers

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The turbulent transition of viscoelastic flows, exhibiting both viscous and elastic effects, shows characteristics distinct from the inertia driven transition processes. Elastic flows can transition to turbulence even for flows with relatively little inertia when the flow elasticity is large, i.e. for flows with large Weissenberg numbers.

Here, direct numerical simulations (DNS) are performed on an elastic mixing layer to study the emergence of turbulence induced by Kelvin-Helmholtz-like (KH) instabilities. In experiments, elastic fluids are typically studied by adding an certain concentration of long-chain polymers. In the present study, the elastic fluid is modeled through the Oldroyd-B model. We vary the Reynolds number in the range of $Re = 10 - 2000$ in a domain initially containing four vortices[1] and the Weissenberg number in the range of $Wi = 0.001 - 10$. Reynolds and Weissenberg numbers are defined based on the initial mixing layer thickness and the velocity difference across the mixing layer. In time, the KH vortices merge until viscous dissipation dampens the flow. Elasticity alters this qualitative picture by triggering chaotic motion even at a negligible level of inertia, in configurations where a simple Newtonain fluid would simply diffuse. This difference is illustrated in Fig. 1.

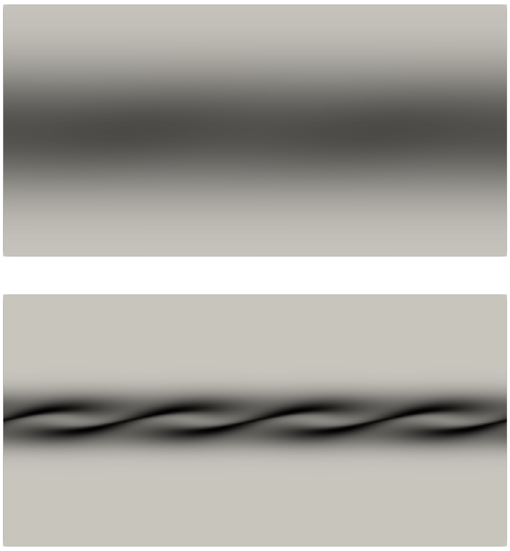

Figure 1: The spanwise component of the vorticity direction at the same time for $Re = 20$ and two different elasticities: (top) $Wi = 0.001$ and (bottom) $Wi = 1$.

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[1]Zayernouri and Metzger, *Physics of Fluids* 23.2 (2011).