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On the origin and evolution of streaks in polymeric shear flows

JACOB PAGE, TAMER ZAKI, Imperial College London — Streaks are a ubiquitous feature in transitional shear flows of both Newtonian and complex fluids. A model problem is formulated where streaks are generated in response to forcing by a decaying streamwise vortex in an Oldroyd-B fluid, and the effects of inertia and elasticity are examined. The dynamics are found to be largely governed by a single parameter: the ratio of the solvent diffusion to the polymer relaxation timescales. When the time scales are disparate, the "quasi-Newtonian" and "elastic" dynamics can be distinguished. The "quasi-Newtonian" evolution of the streaks in the polymeric flow matches the Newtonian equivalent at the same total (solvent) Reynolds number when polymer relaxation is very fast (slow). The "elastic" response is significant, when the polymer relaxation time is long, and leads to significant streak amplification even with very weak inertia. When the diffusion and polymer relaxation timescales are commensurate, the streaks are re-energised in a periodic cycle. This behaviour is enhanced in the instantaneously elastic limit where the governing equation reduces to a wave equation with harmonic forcing. The streak re-energisation is demonstrated to be a superposition of trapped inertio-elastic shear waves.

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