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Transient growth without inertia MIHAILO R. JOVANOVIĆ, SATISH KUMAR, University of Minnesota — We study transient growth in inertia-less plane Couette and Poiseuille flows of viscoelastic fluids. For streamwise-constant 3D fluctuations, we demonstrate analytically the existence of initial conditions that lead to quadratic scaling of both the kinetic energy density and the elastic energy with the Weissenberg number, We. This shows that in strongly elastic channel flows, both velocity and polymer stress fluctuations can exhibit significant transient growth even in the absence of inertia. Our analysis identifies the spatial structure of the initial conditions (i.e., components of the polymer stress tensor at $t = 0$) responsible for this large transient growth. Furthermore, we show that the fluctuations in streamwise velocity and the streamwise component of the polymer stress tensor achieve $O(We)$ and $O(We^2)$ growth, respectively, over a time scale $O(We)$ before eventual asymptotic decay. We also demonstrate that the large transient responses originate from the stretching of polymer stress fluctuations by a background shear and draw parallels between streamwise-constant inertial flows of Newtonian fluids and streamwise-constant creeping flows of viscoelastic fluids. One of the main messages of this work is that, at the level of velocity fluctuation dynamics, polymer stretching and the Weissenberg number in elasticity-dominated flows effectively assume the role of vortex tilting and the Reynolds number in inertia-dominated flows of Newtonian fluids.

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