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Viscoelastic nonlinear traveling waves and drag reduction in plane Poiseuille flow WEI LI, PHILIP STONE, MICHAEL GRAHAM — Nonlinear traveling wave solutions to the Navier-Stokes equations in the plane Poiseuille geometry come into existence at a Reynolds number Re very close to the experimentally observed value for transition to turbulence. These "exact coherent states" (ECS) capture the dominant streamwise-aligned counter-rotating pairs of vortices of the near-wall buffer layer. The present work considers the effect of viscoelasticity on these states, using the FENE-P constitutive model of polymer solutions. These effects mirror many experimental observations in fully turbulent flows near the onset of turbulent drag reduction. The mechanism underlying these changes is suppression of streamwise vortices by the polymer forces. Moreover, all mean velocity profiles on the ECS existence curves collapse onto a universal profile, which is insensitive to polymer extensibility, concentration, Weissenberg number or Reynolds number. In experiments with a given fluid, Reynolds and Weissenberg numbers (Wi) are linearly related. In this situation, we predict that there exist experimental conditions where these states cannot exist at all. Since polymer additives do not relaminarize turbulent flow, these results imply that there must exist other nontrivial states in turbulent viscoelastic flow that exist at high Wi.

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