Abstract Submitted
for the DFD07 Meeting of
The American Physical Society

Near-transition dynamics of viscoelastic turbulence and drag reduction in plane Poiseuille flow LI XI, WEI LI, MICHAEL GRAHAM, Department of Chemical and Biological Engineering, University of Wisconsin-Madison — Nonlinear traveling wave solutions have been found for the Navier-Stokes equations in all canonical parallel flow geometries. These solutions capture the main dynamical features of turbulent flows, especially for near-wall coherent flow structures. Our previous study of the effects of polymer additives on one class of these so-called exact coherent states (ECS) suggests that turbulent drag reduction can be better understood through these traveling waves. Many key aspects of experimental observations can be related with the existence and evolution of ECS solutions in viscoelastic flows. Guided by these results, we conduct direct numerical simulations (DNS) in a minimal flow unit that captures the smallest self-sustaining structure in turbulence. The simulations are performed in a parameter regime close to the laminar-turbulent transition, where our earlier results predict that the laminar-turbulent transition, the onset of drag reduction and the maximum drag reduction (MDR) regime are close to each other in Reynolds number. The connection between these DNS results and traveling waves will be described, and the dynamical structures outside of the existence boundary of ECS will also be investigated, the latter of which could be a good starting point of understanding the nature of MDR.

Li Xi
Department of Chemical and Biological Engineering,
University of Wisconsin-Madison

Date submitted: 04 Aug 2007 Electronic form version 1.4