Abstract Submitted
for the DFD07 Meeting of
The American Physical Society

Dynamics of Hairpin Vortices and Friction Drag Reduction in Turbulent Flow of Dilute Polymer Solutions[1] KYOUNGYOUN KIM, Arizona State Univerisity, RONALD ADRIAN, Arizona State University, S. BALACHANDAR, University of Florida, R. SURESHKUMAR, Washington University, St. Louis
— We portray, for the first time, the nonlinear auto-generation of new vortices and formation of hairpin packets in the presence of polymer stress by performing a series of dynamic simulations and explain the effect of such dynamics on the reduction in turbulent stresses and hence, drag reduction. In the dynamical simulations, an initially isolated vortical structure is evolved in the viscoelastic flow where the polymer stress is modeled by the FENE-P model (finitely extensible nonlinear elastic-Peterlin). The initial conditions are given by the conditionally averaged flow fields for Reynolds-stress-maximizing Q2 event obtained from fully turbulent channel flow at $Re_\tau = 395$ with drag reduction of 0%, 18% and 61%. We found that the threshold of initial vortex strength for the auto-generation of new hairpins increases as the viscoelasticity increases, especially in the buffer layer. The result suggests that the auto-generation of new vortices is suppressed by the polymer stresses, thereby the coherent as well as incoherent Reynolds stress decrease and ultimately turbulent drag is reduced.

[1]Work supported by ONR contract N000140510687.

Kyoungyoun Kim
Arizona State Univerisity

Date submitted: 06 Aug 2007 Electronic form version 1.4