

88f Direct Numerical Simulation of Homogeneous Turbulent Shear Flow with Polymer

Lance R. Collins, T. Vaithianathan, Ashish Robert, and James G. Brasseur

The phenomenon of turbulent drag reduction due to polymer additives has been observed for decades in experiments, and more recently in several direct numerical simulations (DNS) of turbulent channel flow. Most numerical studies use the finite extensible nonlinear elastic model with the Peterlin closure (FENE-P) to describe the polymer stresses. In channel flow, the polymer effect is often associated with the weakening of the counter-rotating vortices in the viscous sublayer causing the sublayer (and log layer) to extend farther into the flow, thereby increasing the flow rate for a given pressure drop. In this talk, we will present results from homogeneous turbulent shear flow that show similar levels of drag reduction as have been observed in channel flows. Here, the connection of the phenomenon with particular turbulence structures is far less clear. The results suggest a more generic description of drag reduction that involves the interaction of polymer molecules with turbulent velocity gradient fluctuations and mean shear. Polymer-turbulence energy exchange is primarily confined to the largest (energy containing) scales, indicating a direct, rather than indirect exchange mechanism. The stretching of the polymer leads to a dramatic reduction in the pressure-strain-rate correlations, essentially starving the turbulence of fluctuations in the direction of the mean flow gradient. This causes the Reynolds stress to decrease, which further reduces the turbulent energy production. The interactions are separately investigated using the DNS database. Additionally, a simple theory to describe the turbulent stretching of polymers will be presented.