129j A Numerical Study of Mixing in Drag-Reduced, Turbulent Flows of Polymer Solutions

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It is well known that small concentrations of polymers can dramatically reduce the skin friction at a solid surface. The possibility of exploiting this phenomenon to reduce drag on ships and underwater vessels has been tantalizing, but never fully realized. One complication is that polymer, injected into the boundary layer to induce drag reduction, will eventually diffuse away. Thus, "persistence" of the polymer effect is an important design parameter for any potential system. We study the mixing characteristics of the polymer using high-resolution direct numerical simulations. Polymer stresses are described by the finite extensible nonlinear elastic model with the Peterlin closure (FENE-P). Consistent with experimental measurements, we observe a reduction in the turbulent flux of polymer that is commensurate with the reduction in momentum (i.e., drag). We will show how the suppression of mixing depends upon the polymer properties (i.e., Weissenberg number and extensibility parameter) and polymer concentration. We will also contrast the mixing of polymer against the mixing of a passive scalar to further highlight the effects of the polymer on the turbulence processes.