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The intriguing mechanism of drag reduction by dilute polymer solutions RAYHANEH AKHAVAN, DONG-HYUN LEE, University of Michigan — The mechanism of drag reduction by dilute polymer solutions is investigated using results from DNS in turbulent channel flow. Drag reductions of up to 56%, corresponding to Virk's MDR, are achieved through a most intriguing, energetically insignificant, yet dynamically significant, mechanism. The cornerstone of this mechanism is a redirection of a small fraction, of no more than 5% on a volume-averaged basis, of the turbulence kinetic energy (TKE) into the elastic energy of the polymer at select turbulent scales. This redirection of energy leads to a decrease in the fluctuating strain-rate at the affected scales, which, in turn, results in a drop in the pressure-strain correlation at these and neighboring scales. The drop in the pressure-strain correlation inhibits the transfer of TKE from the streamwise to cross-stream directions, resulting in a highly anisotropic state at the affected scales. This anisotropy inhibits the normal cascade of TKE to smaller scales. Thus the minute extraction of energy by the polymer initiates a "self-amplifying" sequence of events in which turbulence loses its three-dimensionality and the turbulence energy cascade is inhibited. The magnitude of drag reduction is determined by the range of affected scales, which is a function of We_τ and polymer concentration. For maximum drag reduction, all large scales throughout the channel need to experience the minimal initial extraction of TKE by the polymer.

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