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Skin-Friction Drag Reduction in Turbulent Channel Flow by a Scale-Dependent Molecular Viscosity DONG-HYUN LEE, RAYHANEH AKHAVAN[1], University of Michigan — In prior work, we have proposed that the primary mechanism of drag reduction by dilute polymer solutions is the polymer's extraction of a minute amount of turbulence kinetic energy from the large turbulent scales. Here, we mimic this mechanism by performing DNS with a scale-dependent molecular viscosity in turbulent channel flow. Simulations were performed in channels of size $10h \times 5h \times 2h$ and $40h \times 10h \times 2h$ at a base Reynolds number of $Re_\tau \sim 230$. Drag reductions of 50% and higher were observed when the molecular viscosity was artificially raised from ν_s to $(3-4)\nu_s$ in a band of large-scale wavenumbers corresponding to $0.01 < \sqrt{k_x^2 + k_y^2}/k_d < 0.1$. Many characteristics of drag reduction by dilute polymer solutions were reproduced by the scale-dependent molecular viscosity, including strong anisotropy in the turbulence structure, interruption of the turbulent energy cascade, a pileup of turbulence kinetic energy at the large scales in the streamwise component of the fluctuating velocity, and a shift of the peak of turbulence production away from the wall. These results open up new possibilities for devising novel turbulent skin-friction drag reduction strategies in wall flows.

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Rayhaneh Akhavan
University of Michigan

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