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New approaches to turbulent skin-friction drag reduction in wall flows based on the mechanism of drag reduction of polymer additives
RAYHANEH AKHAVAN, DONG-HYUN LEE, University of Michigan, Ann Arbor, MI, 48109-2125 — Polymer additives provide one of the most effective means of skin-friction DR in wall flows. Recent insights into the DR mechanism of polymer additives reveals that the cornerstone of high DR with polymer additives is redirection of a small fraction of TKE from energy-containing eddies into a path other than the normal turbulent energy cascade. This redirection of energy initiates a self-amplifying sequence of events within the turbulence dynamics, through which the turbulence loses its three-dimensional structure and turbulence production is suppressed. This mechanism suggests that the same dramatic DRs observed with polymer additives can be reproduced through *any* mechanism which redirects a small fraction of TKE from energy-containing eddies into a path other than the normal turbulent energy cascade. This hypothesis has been tested using DNS in turbulent channel flow, where the molecular viscosity in a small band of wavenumbers, corresponding to $0.01 < k/k_d < 0.1$, was increased from ν to 4ν. Drag reductions of up to 54%, comparable to that observed with polymers at MDR, were observed, and many of the flow features observed in DR with polymer additives were reproduced. These results open up new possibilities for devising novel DR strategies for wall flows.

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