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Energy budget in lubricated drag-reduced turbulent channel flow
ALESSIO ROCCON, FRANCESCO ZONTA, ALFREDO SOLDATI, TU Wien / University of Udine — We use direct numerical simulation to study the problem of drag reduction in a lubricated channel, a flow instance in which a thin layer of a lubricating fluid (density ρ_1, viscosity η_1, thickness h_1) is injected in the near-wall region of a plane channel, so to favor the transportation of a primary fluid (density ρ_2, viscosity η_2, thickness h_2). The primary and lubricating fluids have the same density but different viscosity, such that a viscosity ratio $\lambda = \eta_1/\eta_2$ can be defined. Building on a sound flow characterization, we show that significant drag reduction (DR) can be achieved. Reportedly, the observed DR is a non-monotonic function of λ and, in the present case, is maximum for $\lambda = 1.00$ ($\simeq 13\%$ flow rate increase). For the cases $\lambda \leq 1.00$ (low-viscosity lubricating fluid), and confirming previous investigations, we show the existence of two different DR mechanisms: when the two fluids have the same viscosity, DR is purely due to the effect of the surface tension. When the viscosity of the lubricating layer is reduced, turbulence can be sustained in the lubricating layer and DR is simply due to the smaller viscosity of the lubricating layer that acts to decrease the corresponding wall friction.

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