Inertial-layer Mean Velocity Profiles for extreme Reynolds number flows

FABIO RAMOS, HAMIDREZA ANBARLOOEI, DANIEL CRUZ, Federal University of Rio de janeiro — For fully developed statistically stationary channel and pipe flows with smooth walls, any averaged quantity of the flow at a distance \( y \) from the wall can be specified by the control parameters \( \rho, \mu, u_r \) and \( y \) itself. By the Pi theorem, there exist only three non-dimensional groups that can be formed from the combination of \( \langle u \rangle(y) \) or \( \frac{d\langle u \rangle}{dy}(y) \), and those quantities. In an earlier work, by observing that center of the log-law scales as the geometric mean \( \sqrt{\delta \nu} \), we have proposed an attached eddy framework, which results on a new friction factor formula for extreme Reynolds number, namely \( f \sim \frac{1}{Re^{2/3}} \). In this work, by assuming incomplete self-similarity, we show that the new friction factor is compatible with a new MVP formula, namely \( \langle u \rangle(y) = u_r \Phi \left( \frac{y}{\sqrt{\delta \nu}} \right) \), which in wall units result in the new expression \( u^+ = A (y^+)^{1/12} + \frac{B}{Re^{1/2}} (y^+)^{1/6} \). This formula, with only two free parameters, results in a very good fit for the MVP data obtained from Princeton superpipe experiments, for a large range of extreme Reynolds number, \( Re > 10^7 \), and for a large radial extension above the log-law range.