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Modified law of the wall leading to turbulent channel flow universal velocity profiles valid down to $Re_\tau = 395$
GREGOIRE WINCKELMANS, UCL, Louvain School of Engineering, LAURENT BRICTEUX — Velocity profile modeling is revisited using the results from databases of turbulent channel flow DNS at $Re_\tau = u_\tau\, h/\nu = 2000$, 950, 550, and 395. We consider the turbulent region: $y^+ = Re_\tau\, \eta$ (with $\eta = y/h$) larger than 70). A new model for the effective turbulent viscosity, $\nu_t = -\overline{u'v'}/\frac{d\overline{u}}{dy}$, is proposed, that fits well the DNS results all the way to the channel center. The velocity profile is then obtained by integration: it corresponds to a "modified law of the wall," $\frac{1}{\kappa}\left(\log(y^+ + y_0^+) - \eta\right) + C$, with the added classical "law of the wake," $D\, g(\eta)$. The new $-\eta$ term in the modified law of the wall is really required in such still limited Reynolds number channel flows, as an important correction to the usual log term: both terms "work together," as both are multiplied by the same $\frac{1}{\kappa}$ value (recall that D is not related to κ). Only at the highest Reynolds numbers does this correction become negligible. As to the y_0^+ shift in the log term itself (value around 6), something also recently proposed by Spalart et al (Phys. Fluids in press), it too is required as a consequence of the ν_t near wall behavior. The present velocity profile is quite universal: it fits very well, with the same value of all constants, all Re_τ cases. In particular, the von Kàrmàn constant is obtained as $\kappa = 0.37$: same as Zanoun et al (Phys. Fluids 15 (10):3079, 2003), and close to 0.38 as Spalart et al.

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