The Diagnostic Plot and its Implications for High Reynolds Number Wall-Bounded Turbulent Flows

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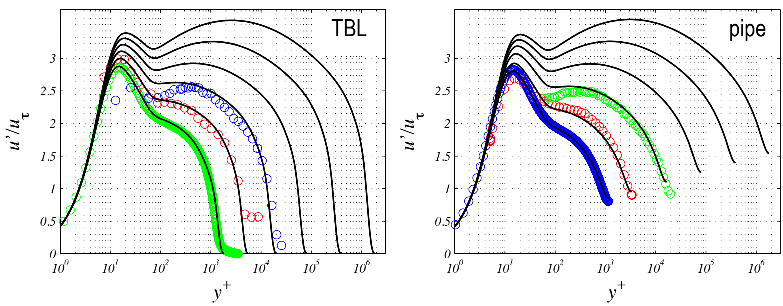
The distribution of the streamwise velocity turbulence intensity has recently been discussed in several papers both from the viewpoint of new experimental results as well as attempts to model its behaviour. Recently, the so called "diagnostic plot" has been suggested that can be used to judge wall bounded turbulence data of the mean (U) and the rms (u') of the streamwise velocity in terms of reliability both near the wall, around the maximum in the rms, as well as in the outer region. The important feature of the diagnostic plot is that neither the wall position (y) nor the friction velocity (u_τ) needs to be known, since it shows the rms value as a function of the streamwise mean velocity, both normalized with the free stream velocity. This is in particular an advantage from an experimental point of view, since both the friction velocity as well as the wall position are difficult to obtain with high accuracy, or even impossible with rough wall conditions.

Based on the diagnostic plot, it was found that in the outer region of the boundary layer a universal linear decay of the turbulence intensity independent of the Reynolds number exists. This approach has been generalized for turbulent channel and pipe flows, as well as for boundary layers (TBL) over smooth and rough wall surfaces. These results lay the foundation for new empirical fits for the streamwise velocity turbulence intensity distribution of wall-bounded flows. Coupled with a mean streamwise velocity profile description the model provides a composite profile for the streamwise rms profile that agrees nicely with existing numerical and experimental data (see figure). Extrapolation of the proposed scaling to high Reynolds numbers predicts the emergence of an outer peak that at even higher Reynolds numbers overtakes the inner one (see figure).



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