DIAGNOSIS OF WELL-BEHAVED TURBULENT BOUNDARY LAYERS

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The assessment of effects such as inflow conditions, tripping devices and development length on the characteristics of zero pressure gradient (ZPG) turbulent boundary layers (TBLs) has started to receive some renewed attention. The problem is extremely relevant, as such effects may lead to local non-equilibrium conditions, producing flows which are no longer representative of *canonical* ZPG TBLs. Development of TBLs towards canonical conditions have from early days of turbulent-boundary-layer research (Coles, 1968) been assessed based on the streamwise evolution of quantities such as the skin-friction coefficient, the shape factor and the wake parameter, and this is still the common way in the literature (Chauhan et al, 2009). Extensive analysis of a wide range of experimental databases has led to a number of empirical relations for the evolution of these three parameters, and convergence towards canonical conditions is commonly assessed with respect to such reference curves. Their assessment is, however, strongly dependent on accurate wall-shear measurements, an accurate determination of the wall-position with respect to the measurement probe and detailed near-wall measurements at several streamwise locations; thereby requiring an extensive measurements campaign to simply assess the state of a ZPG TBL. The choice of tripping strategy and inflow conditions has recently also been found to significantly affect the results from direct numerical simulations (Schlatter and Örlü, 2010, 2012), thereby emphasising the importance of the proper choice of inflow and tripping in both wind-tunnel experiments and simulations.

In the present talk, the state of the art in assessing canonical conditions in ZPG TBLs will be reviewed, and a practical method based on the diagnostic-plot (Alfredsson et al, 2011) will be proposed to diagnose *well-behaved* ZPG TBLs (Sanmiguel Vila et al, 2017). An inherent advantage of the diagnostic method is that it only requires the streamwise mean velocity and turbulence intensity at arbitrary wall-normal distances (as demonstrated in Figure 1), thereby relying only on directly measured quantities.

References

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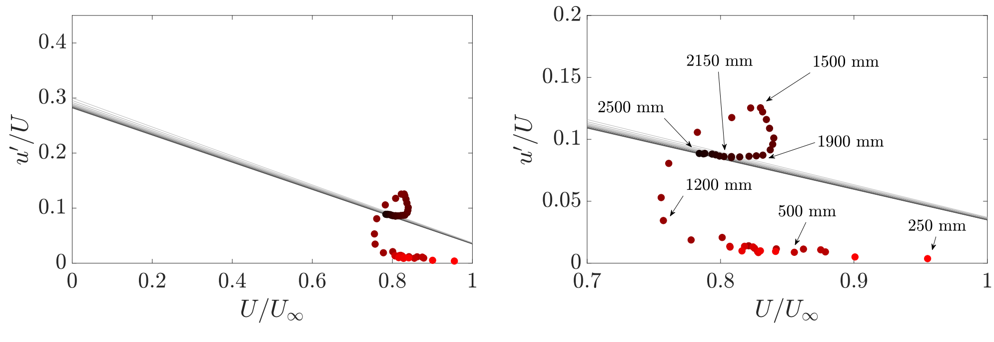

Figure 1. a) Diagnostic-plot methodology as a design tool demonstrated using data from a ZPG TBL with a weak and very late tripping. b) Zoom-in of a) with indicated streamwise locations from leading edge of the measurement points taken with equidistant streamwise spacings of $\Delta x = 50$ mm.