EXPERIMENTAL INVESTIGATION OF COHERENT STRUCTURES IN A FLAT PLATE TURBULENT BOUNDARY LAYER AT RE$_{\Theta}$=10,000

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The production of viscous drag within the *turbulent boundary layer* (TBL) leaves still unresolved questions in turbulence research. Coherent structures consisting of large meandering formations of positive and negative streamwise velocity fluctuations in the upper log-layer contribute to the near-wall stress-producing cycle as well [1]. The interplay between these large-scale structures and those of the near-wall, which can be clearly separated from each other for high Reynolds numbers ($Re_{\Theta} > 1{,}500$) [2], is of considerable importance for getting a detailed understanding of turbulence length scales and spectra. For this reason, measurements were carried out on a zero pressure gradient flat plate that was installed in the DLR (*German Aerospace Centre*) low-speed wind tunnel SWG (*Cross Wind Test facility Göttingen*). The flat plate model was 7.67 m long and 2.39 m wide. In order to guarantee the development of a TBL without disturbances from the boundary layer of the wind tunnel floor, the flat plate was mounted 400 mm above and parallel to the bottom of the test section. Different measurement techniques were applied at a region of interest located 6.9 m ($x = 0$) downstream of the elliptical leading edge of the flat plate model: On the one hand, flow investigations were made using three overlapping stereo-PIV-systems (*Particle Image Velocimetry*) with a measurement plane perpendicular to the flat plate (Fig.1-left). The complete TBL thickness was captured, whereas special attention was paid on the detection of large-scale motions in the upper log-region over a long distance. Additionally, for getting the full velocity information in the near-wall region of the TBL, the Multi-Pulse Shake-The-Box 3D Lagrangian Particle Tracking measurement technique (MP-STB) [3] was applied to a field of view of about $80 \times 120 \times 10$ mm^3 in streamwise, spanwise and wall-normal direction, respectively. Velocity vectors measured at randomly distributed tracks within the measurement volume have been interpolated by the Navier-Stokes-regularized interpolation method FlowFit [4] for the purpose of determining the full velocity gradient tensor. On the right in Fig.1, iso-surfaces of the Q-criterion gained by FlowFit interpolation of an instantaneous MP-STB result (97,000 tracks) are shown. Even small scale vortical structures within the volume can be resolved. For both measurement setups, a statistical significant number of samples has been acquired which provides a huge database for a detailed structure analysis of the coherent structures (e.g. with two-point-correlations). Especially the interactions of these structures within the near-wall and log-region will be examined.

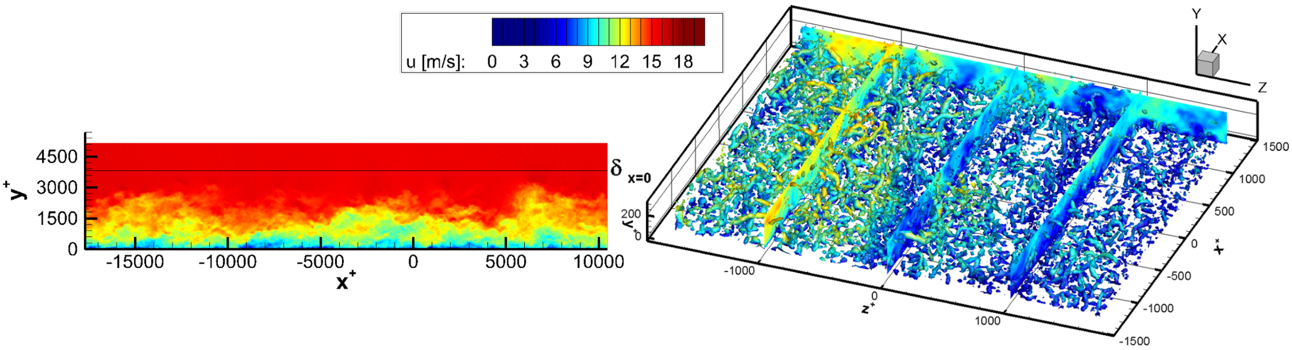

Figure 1. Left - Instantaneous u-velocity distribution measured by multiple stereo-PIV-systems at $Re_{\Theta} = 10,000$. Right - FlowFit interpolation of instantaneous MP-STB result showing the iso-surfaces of Q-criterion ($Q = 2{,}000{,}000$).

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