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Adverse pressure gradient effects on the turbulent boundary layer around a NACA 4412 wing profile: an experimental investigation

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The effects of non-equilibrium adverse pressure gradients (APGs) on the turbulent boundary layer (TBL) developing around a NACA 4412 wing profile are studied experimentally in the Minimum Turbulence Level (MTL) wind tunnel at KTH. Two Reynolds numbers (0.4 and 1 x 10^{6}) and four angles of attack (5, 8, 11 and 14 degrees) are investigated in the present campaign. Special focus has been put on a clean setup of the cases, allowing for high-accuracy measurements of the turbulent flow: In order to characterize the TBL, pressure scans and hot-wire anemometry (HWA) measurements are conducted. Amplitude modulation and spanwise coherence of the TBL subjected to strong APGs is assessed through two-point HWA correlation measurements in the wall-normal and spanwise directions. Moreover, oil-film interferometry is used as a direct measurement of the skin friction, avoiding the estimation of the friction velocity (critical for scaling of the data) from composite profiles. A thorough analysis of the current data and of existing APG databases show that such estimation may be inadequate for strong adverse pressure gradients (such as the ones occurring around a wing). Lastly, the experimental data acquired is thoroughly cross-validated against adaptive high-fidelity (quasi-DNS) numerical simulations[1] conducted with the spectral-element method Nek5000. As seen in Figure 1, an excellent agreement is observed both in the pressure coefficient around the wing, as well as in the mean velocity profile in the boundary layer for matching simulations and experiments.

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[1] Tanarro et al., *Flow Turb. Combust.* **105 (2)**, 415 (2020).
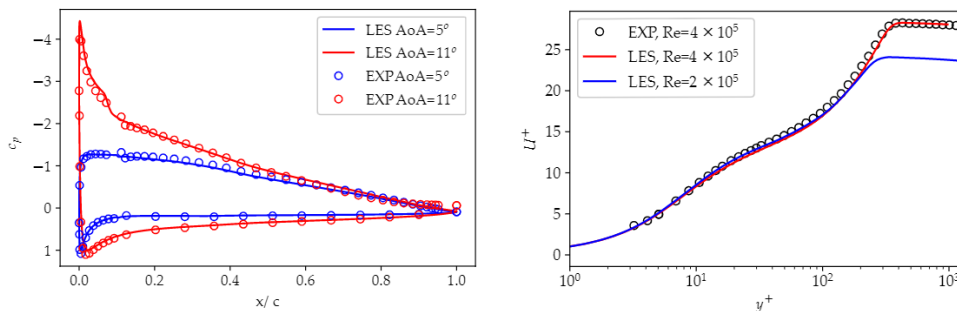

Figure 1: Cross-validation of the LES and experimental data. Pressure coefficient distribution (left) and boundary layer mean velocity profile at x/c=0.75 and AoA=5° on the suction side (right).