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Numerical Investigation of TS-Wave Growth Over Surface-Steps on a Laminar Profile with Suction

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The aerodynamic design of laminar profiles with suction is generally carried out by Linear Stability Theory (LST) as a quick and reliable prediction-tool for the transition-position. Alternatives, like direct simulations of transitional modes, have shown promising results for the understanding of the scientific background under special flow-conditions, for cases where basic assumptions of classic LST are violated. A typical geometric singularity of this class, is the forward- or backward facing step, violating the parallel-flow assumption at corners that require a special singularity-treatment, as demonstrated by Zahn and Rist [1]. For Tollmien-Schlichting (TS) modes, a two-dimensional approach of the perturbed boundary-layer flow-field is not very time-consuming and allows the investigation of TS-modes over even complicated geometries, including the non-linear growth effects.
Future experiments on the laminar leading-edge of a vertical-tail model are planned with suction-panels for Hybrid Laminar Flow Control (HLFC) by sealing two suction panels with a thin tape, resulting in additional forward- and backward facing steps. Laminar flow-stabilization by suction is expected in front and downstream the taped region. Especially the backward facing-step shows strongly destabilizing influences on the TS-modes. The character of the dominating TS-waves allows 2D simulations of the flow-field by using a well-validated high-order numerical approach [2] which will be sufficient for a detailed simulation of transitional modes in the region of interest. To demonstrate sufficient transition suppression by the suction-panel with or without sealing-tape, direct numerical simulations of critical TS-modes are prepared (see [2]), including post-processing and comparison with growth-rates on unperturbed surfaces and stabilization by uniform suction. The strong stabilizing effect of such approaches was already successfully calculated by Rist and Zahn [1].

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