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Resonant Interactions of 3D Instability Waves in an Airfoil Boundary Layer for Harmonic and Broadband Perturbations

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This paper is devoted to a systematic experimental investigation of resonant interactions of Tollmien-Schlichting (TS) waves occurred at weakly-nonlinear stages of the laminar-turbulent transition in a non-self-similar boundary layer on an airfoil with a long laminar run. The paper is aimed to analyze the importance of the TS-wave interactions in dependence on the base-flow and disturbance parameters in order to clarify two main questions: (i) how does the base flow non-uniformity influence the efficiency of the resonant interaction and (ii) when are these interactions important for the transition prediction. The experiments were carried out at controlled disturbance conditions. The TS-waves were excited in the boundary layer by a specially designed disturbance source. Several dozens of initial disturbance spectra were examined, including cases of simple tuned subharmonic triplets, regimes with frequency and spanwise-wavenumber detunings, multi-wave regimes, and regimes with excitation of broadband perturbations simulating some “natural” transition conditions. The base flow non-self-similarity is found to influence significantly the nonlinear disturbance interactions. Several unusual properties of such interactions have been detected and investigated.

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