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3D Distributed Boundary-Layer Receptivity to Non-Stationary Free-Stream Vortices in Presence of Surface Roughness

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The paper is devoted to investigations of the three-dimensional (in general) problem of boundary-layer receptivity to non-stationary free-stream vortices (with spanwise and wall-normal orientations of the vorticity vector) due to their scattering on distributed surface non-uniformities. The main goals of the study are: (i) to develop a method of experimental determination of the distributed vortex-receptivity coefficients and (ii) to obtain their experimental values. The experiments are performed at controlled disturbance conditions. It is found that for the two studied free-stream vortex orientations the Tollmien-Schlichting waves are excited in the boundary layer in a distributed way despite in the case of the spanwise orientation the distributed receptivity is much weaker than for the wall-normal orientation. The receptivity coefficients are obtained both for the distributed vortex receptivity on smooth surface and for the roughness-vortex distributed receptivity. It turned out that the two types of the receptivity mechanisms, investigated in the wall-normal vorticity case, are the strongest for the free-stream vortices having the largest spanwise scales. An important role of streamwise-wavenumber resonances of evolved perturbations is shown and analyzed.

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