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Investigation of structures of the late non-linear boundary layer transition using Stereo PIV

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ABSTRACT

Stereoscopic (SPIV) and standard PIV measurements on acoustically excited transitional boundary layer flows along a flat plate with zero pressure gradient and additionally along an airfoil will be presented. The experimental results are focused on the structures of the late stages of K- and oblique type transition in case of the flat plate and on comparable structures in the case of an airfoil boundary layer flow excited by a point source.

Instantaneous velocity fields are examined in order to quantify the local and global dynamics of the structures and velocity distributions leading into breakdown. Moreover the experimental results will be compared with spatial DNS and previous investigations.

The comparison shows a good correspondence of our data as well with former experimental results as with the spatial DNS. Location and multi-spike characteristics of the wall normal motion on top of the Λ -vortices as one of the first sources for shear stress decomposing the transitional structures towards turbulence agree quite well. Also a good correspondence is found for the oblique type of transition, where non-linear generated high- and low-speed streaks cause shear stress due to large velocity gradients at their crossings. On the other hand the SPIV results exclude the presence of frequently predicted streamwise vortices at these crossing positions.

A generic forming process can be assumed for the main part of the non-linear stage where mostly 3D disturbances interact with deformed Tollmein-Schlichting (TS)-waves to Λ -shaped and streaky structures. This thesis can be confirmed, since some important local processes measured with SPIV are in good correspondence with DNS even for his late stage of transition.

For the point source excited airfoil boundary layer flow we also found a good agreement between the shape, location and quantity of the structures in the PIV results and the spatial DNS, especially for the characteristic M-structure consisting of two Λ -waves in the experimental data-set.