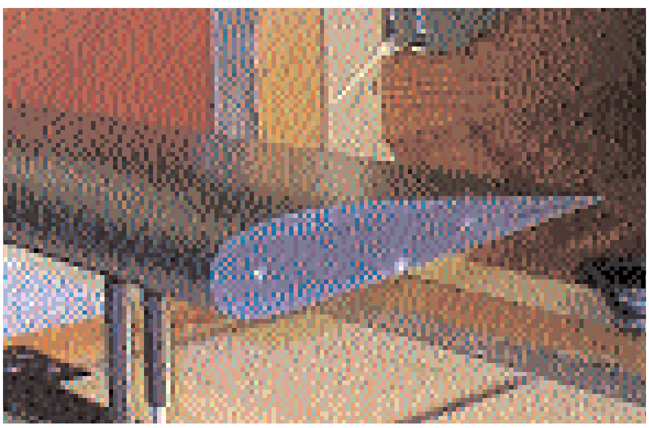
Fundamental Fluid Dynamics Research

Patterns of streamwise lambda structures mapped with MiniCTA hot wire anemometry

Understanding of wall bounded turbulence phenomena is an important issue for the implementation of reactive flow control. This is especially true in drag reduction, where the control of coherent structures formed on aircraft wings plays a key role. The flow structure of the innermost part of the turbulent boundary layer is typically quasi-periodic with intermittent bursting events, and this requires simultaneous sampling of data from multiple-sensor arrays.

Particularly suitable equipment for such multi-point measurements is the MiniCTA, which has a bandwidth, noise and stability specification designed for such measurements. In addition, its small size and affordability make it advantageous for multi-sensor measurements. Recently this equipment has been used for the study of controlled patterns of streamwise velocity disturbance components, known as Λ structures, at the department of Thermo & Fluid Dynamics, Chalmers University of Technology, Sweden.



Experimental facility. (Probe, traversing and wing profile).

The measuring system used consists of 8 MiniCTAs, a PC running under Windows NT, and a Iotech WaveBook data acquisition system, which performs simultaneous sampling from 8 channels with 16 bits resolution and sampling rates up to 1 MHz. The probe is moved by means of a fully automatic traverse system with a positioning accuracy of 0.01 mm, which allows measurements down to less than 0.1 mm from the wall.

In order to design a suitable multi-wire probe, preliminary measurements were carried out with a single-sensor boundary layer type probe (Dantec Dynamics 55P15). The test object was a wing profile where the boundary layer was excited from a periodic pressure source, which was also used to trigger the data acquisition. Data were acquired in 33,000 positions inside the boundary layer.

Data reduction was performed in MATLAB where ensemble averaging of the phase locked time series at each point provided data frames with velocity U and turbulence intensity Tu as a function of time. Figure A shows patterns of the streamwise lambda structures as iso-kinetic surfaces. It is clearly demonstrated how horse-shoe eddies are formed and grow along the chord of the profile, and how they are lifted out of the boundary layer. These experimental results give a most detailed presentation of wall-bounded flow structures.

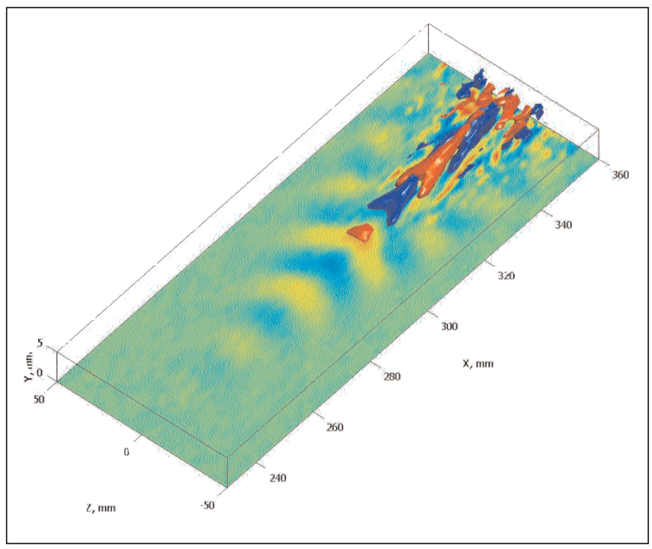


Figure A. The structure of turbulent spots on a wing profile. The experiment shows patterns of the streamwise lambda structures as iso-kinetic surfaces. It is clearly demonstrated how horseshoe eddies are formed and grow along the chord of the profile, and how they are lifted out of the boundary layer.

Acknowledgement

Figure A courtesy of A. Bakchiniov, V. Chernoray, V. Koslov and L. Löfdahl, Thermo and Fluid Dynamics, Chalmers Technical University, Sweden and Institute of Theoretical and Applied Mechanics, Russia.

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Publication No.: CTA1