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### Temporal analysis of coherent structures in a turbulent BFS flow with PIV

by

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#### ABSTRACT

The phenomenon of flow separation and reattachment over a backward facing step geometry is investigated in the turbulent regime ( $Re_h = 5000$ ) by means of particle image velocimetry (PIV). The arrangement of the water flow facility with controlled fluid temperature allows achieving a field sampling frequency twice the convective reference frequency, which is satisfactory for the large-scale fluctuations analysis. High spatial resolution ( $\mathbf{D}/h = 1/30$ ) is obtained with the application of an iterative image processing algorithm that applies window deformation and a multigrid analysis method. The behavior of the unstable shear layer is investigated along several planes such to describe both primary instabilities (spanwise vortices) as well as the vorticity transfer from the spanwise to the streamwise direction.

The time sequences of the velocity distribution are analyzed with a pattern recognition technique. Span-wise aligned vortices shedding in the separated shear layer are observed through their footprints in the streamwise wall-normal plane. A vortex detection algorithm based on pattern recognition analysis is applied, which allows determining the position and relative size of the recognized events. The eduction procedure is completed by means of conditional statistics yielding the coherent flow properties (vorticity, strain-rate, turbulence production, etc.).

Measurements (time sequences) in the  $x$ - $y$  plane yield evidence of an effective vortex shedding mechanism occurring at about the step edge. The complex flow interaction ascribed to a pairing process causes intense vorticity fluctuations downstream the step where multiple structures roll-up as a whole. The tracking of spanwise vortices shows that the shedding structures are likely to be convected in the shear layer rather than follow the mean streamline to the reattachment location.

Instantaneous measurements in the  $y$ - $z$  plane reveal secondary flows of considerable strength taking place in the form of a system of counter rotating streamwise vortices.

Conditional data averaging is applied to the results and structural properties (coherent velocity, vorticity and turbulence production) are obtained for individual vortices.

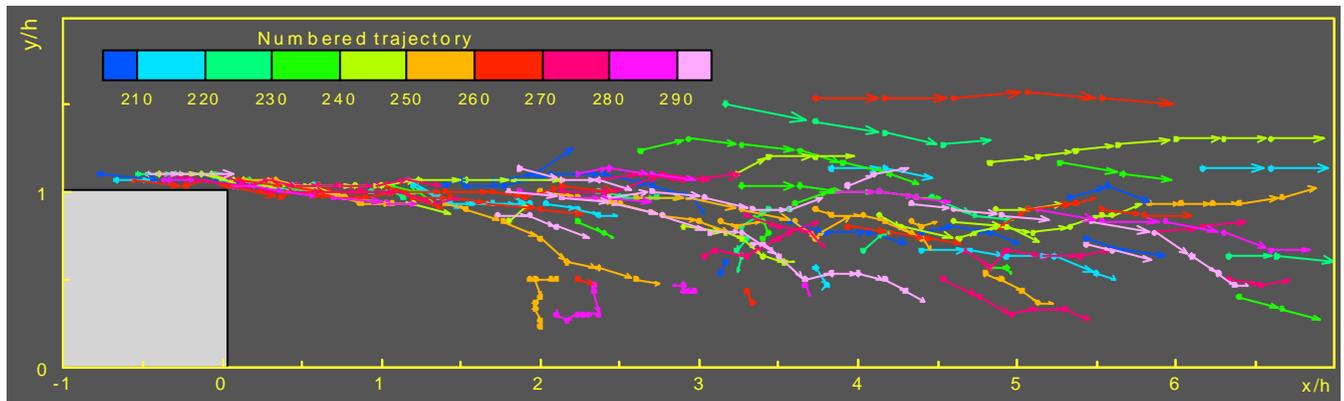


Figure 1 Vortices tracked over the BFS (time step  $t = h/2U_0$ ). The vortex center velocity is indicated with its vector and the individual trajectories are color-coded.

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