Doppler global velocimetry in wind tunnels implementation issues and performance analysis

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Over the past few years, ONERA has performed DGV measurements in wind tunnels, -some of them in cooperation with DLR (ETW Cologne and ONERA F2) -, testing different configurations with the aim of improving the technique and making it available in an industrial context. First, the major key-elements of such a system are discussed: on-line laser frequency measurements, optimization of emission/reception configurations, compromise between sensitivity and scattering efficiency, multiple light sheets versus multiple camera systems. The optimized solution is then confronted with limited optical accesses, light reflections on walls or model to iterate the design of the final configuration. The results of two main experiments are then presented:

- The half-wake of a transport aircraft model in a landing configuration was investigated in F1, a large industrial ONERA facility (Figure 1). The size of the field of view, the ability to follow on-line variations of the angle of attack or Mach number, makes this test conclusive as regards the interest of mean 3C velocity maps.
- The tip vortex developing in the wake of a 2D symmetrical airfoil was previously studied in the ONERA F2 research facility. This model was used to simulate a flap in the frame of the prediction of aerodynamic noise sources location and LDV measurements were available. The DGV experiment was conducted in cooperation with DLR. A composite system was built to take advantage of the skills and hardware of the two teams. Velocity maps were obtained for various angles of attack and positions in the wake, showing a very good agreement with LDV measurements (Figure 2).

The results in a transonic wind tunnel will also be recalled to illustrate the ability of DGV to tackle high-speed flows. In all these campaigns, comparisons with established velocimetry techniques such as LDV, pressure probes or PIV are our major concern, as they represent the best way to assess the accuracy.

Finally, the potential of DGV to give on-line three-component mean velocity maps is confronted to the needs expressed by the wind tunnel operator community and airplane manufacturers in terms of on-line diagnosis to determine the influence of aerodynamic or geometrical parameters during the course of experiments: angle of attack, Mach number, flaps or ailerons settings …

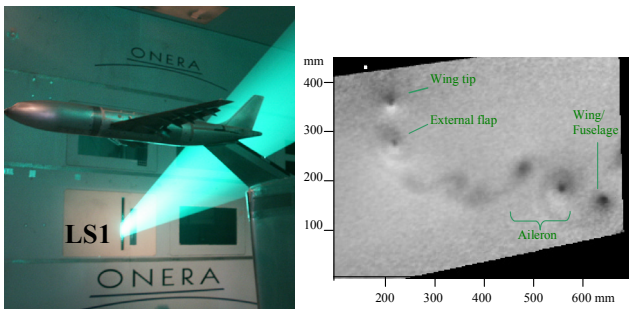

Fig. 1 Transport aircraft model in the ONERA F1 facility Measurement plane materialized by a laser light sheet (left) Doppler shift map showing the vortices in a half-wake(right)

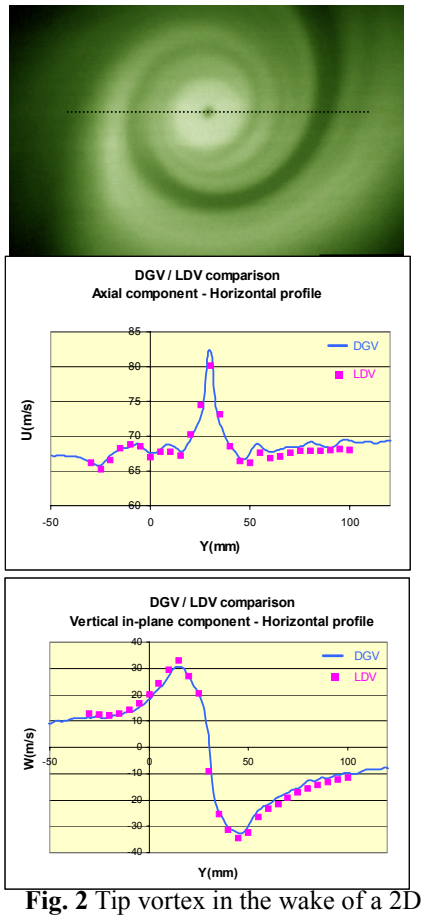

Fig. 2 Tip vortex in the wake of a 2D airfoil in the ONERA F2 wind tunnel. Doppler map (top). Velocity profiles through the vortex: DGV/ LDV comparison