

Performance and accuracy investigations of two Doppler global velocimetry systems applied in parallel

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Two Doppler global velocimetry (DGV) systems were applied in parallel to assess their performance in wind tunnel environments. Both DGV systems were mounted on a common traverse surrounding the glass-walled 1.4×1.8 m² test section of the ONERA F2 wind tunnel facility. The traverse system normally supports a three-component forward-scatter laser Doppler velocimetry system. The reproducible vortical flow field generated by the blunt tip of an airfoil (300 mm chord) was chosen for this investigation and was precisely surveyed by LDA just prior to this investigation serving as a reference data base for the DGV measurements.

Both DGV setups shared the same continuous wave laser light source (argon ion, 514 nm), laser frequency stabilization and fiber optic light sheet delivery system. The principle differences between the DGV implementations are with regard to the imaging configuration. Configuration -A- chosen by ONERA relied on a single camera view that observed three successively operated light sheets (Fig.1, left). In the second configuration chosen by DLR, three camera views simultaneously observed a single light sheet using a four-branch fiber imaging bundle (Fig.1, middle).

Both configurations were characterized by off-normal viewing arrangements: configuration -A- observed two light sheets (LS1, LS3) in forward scattering and one in back-scattering mode (LS2) at a roughly ten times lower signal level. Configuration -B- had all viewing directions at a similar forward scattering angle, such that all views had approximately the same signal levels at the exit of the fiber imaging bundle. Based on the respective viewing arrangements the sensitivity of both systems is similar, with

configuration -A- achieving slightly higher velocity sensitivity due to the backscatter view of light sheet LS2.

The closed-circuit wind tunnel was seeded globally with sub-micron oil droplets using an oil-based smoke generator. Stream-tube seeding was used in addition to improve the signal of the back-scatter views. CCD camera exposures varied from 0.5-2 seconds in forward scattering views to 2-5 seconds in back scattering views.

With a common field of view of roughly 120×120 mm² at 250-450 mm downstream of the airfoil the two DGV systems acquired image data in parallel and thus ensured essentially equivalent measurement conditions. The laser frequency drift was monitored during the measurements by imaging the output of several fibers containing Bragg-shifted as well as un-shifted laser light.

Comparison of the DGV data with LDV measurements shows very good agreement to within 1-2 m/s with DGV slightly underestimating the velocity gradients (Fig. 1, right). The remaining discrepancies have a variety of causes, some are related to the reduced resolving power of the fiber imaging bundle system (graininess, smoothing), exact localization of the receiver head with respect to the scene, laser drift or background scene illumination. The latter was found to impart a velocity bias to the data acquired by the fiber bundle system. Black felt in the background of the single view camera system avoided this problem. In conclusion the single view camera system achieves higher accuracy and spatial resolution while the fiber imaging bundle has the benefit of fast image acquisition since all views are recorded simultaneously.

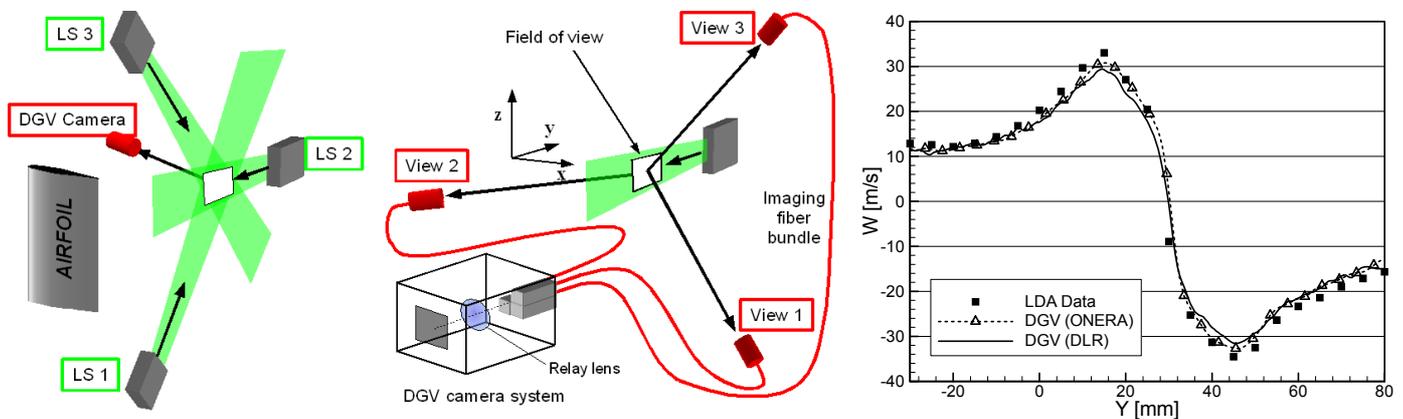


Fig. 1 DGV light sheet and imaging configurations applied in this investigation. **Left:** triple light sheet – single camera setup used with ONERA camera system. **Middle:** Single light sheet – triple camera setup used by DLR setup. **Right:** Comparison between DGV and LDA velocity data for the vertical velocity component through the core of the wingtip vortex.