Paper 2.1

Light-in-flight holography with switched reference beams for cross-correlation in deep volume PIV

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ABSTRACT

We present a holographic PIV system which extends the standard PIV analysis scheme of two velocity components (2D2C) to the third dimension and overcomes the disturbing background light in deep volume images reconstructed from particle holograms. In a light-in-flight holography (LiFH) setup the short coherence length of a modified laser source is used to suppress light from out-of-focus regions. The whole flow field is recorded at one instant of time, but only a small shell of the object space is reconstructed from a limited aperture on the hologram. A plane inside the virtual image is then digitized by a CCD imaging system. The position in depth of the reconstructed shell can be adapted when a corresponding aperture on the hologram is chosen. Thus imaging in turbid media (e.g. deep volume flow field seeded with particles) is possible not only for visualization but also for PIV analysis if an appropriate tracer density is achieved. As an illustrating example figure 1 shows a visualization of a vortex structure in a boundary layer of an axisymmetric jet obtained with a basic LiFH setup also used for holographic PIV. For this purpose only the nozzle flow has been seeded.

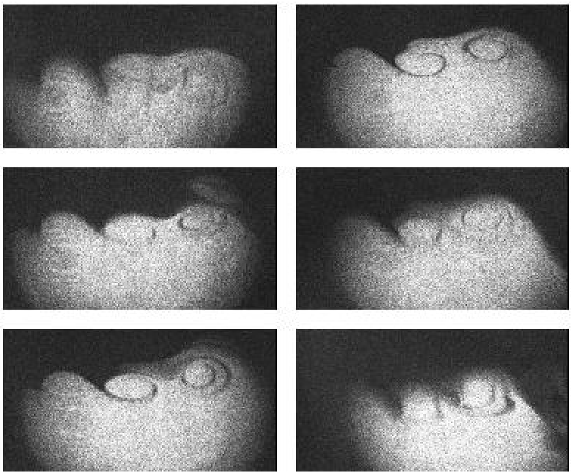

Fig. 1 *Plane-wise sampling of a three-dimensional vortex structure in the boundary layer between an axisymmetric jet and surrounding air. Field of view 44 ´ 70 mm^2, at a distance 30 mm downstream of the nozzle, image planes equally separated over 35 mm depth. The lower field boundary coincides with the nozzle axis.*

For cross-correlation analysis of PIV images two holograms are superimposed on one plate. For this purpose the reference beam direction from a double-pulsed ruby laser is switched between exposures electro-optically by a combination of Pockels cell and a polarizing beam splitter. Cross-correlation algorithms show a much grater tolerance to depth noise and even the LiFH-PIV principle can thus be improved. The novel system is applicable to small scale flows even in turbulent state and offers instantaneous two-dimensional velocity measurements over a deep volume with resolutions well comparable with standard PIV. The performance is demonstrated in studies on the onset of turbulence in a free air flow behind a circular nozzle.