13th Int. Symp on Appl. Laser Techniques to Fluid Mechanics, Lisbon, Portugal, June 26 – 29, 2006

Comparison between PIV measurements from high-speed (CMOS) and cross-correlation (CCD) systems in a jet flow

Massimo Falchi, Giovanni P. Romano

Department of Mechanics and Aeronautics, University “La Sapienza”, Roma, Italy, romano@dma.ing.uniroma1.it

Keywords: PIV acquisition, high-speed PIV, circular jet

In this paper, a comparison between a PIV system based on cross-correlation camera plus pulsed Laser and another using high-speed camera plus continuous Laser is performed. The objective of the paper is to point out advantages and disadvantages of one system in respect to the other when computing large and small flow scale statistics.

The comparison is performed on the velocity field in the near field of a circular water jet: this is a region in which several experimental data and empirical self-similarity laws can be used for performance evaluation. The results show that both systems are suitable for measurements: there is a slight preference for the cross-correlation one when considering single-point statistics of velocity or velocity derivative (due to lower number of effectively independent samples and to larger seeding noise in the high-speed system). In Figure1, the non dimensional isotropic form of the turbulent kinetic energy dissipation

$$\varepsilon_{iso} = 15\nu\overline{\left(\frac{\partial u}{\partial x}\right)^2}$$

is presented as evaluated from data acquired with cross-correlation and high-speed systems respectively. It is made dimensionless by the jet nozzle diameter and the local velocity field. It is clearly possible to see alternate (more or less inclined) brighter and darker stripes especially in the results of the high-speed system. This is an example of the disturbances due to seeding particles settling on the lower tank wall which is a severe problem in evaluating velocity derivatives as in ε_{iso}.

On the other hand, the results from the high-speed system are of better quality when considering multi-point statistics. In Figure 2, the third-order structure functions for the two PIV systems are presented. They both reproduce the expected power-law behaviours in the dissipative and inertial ranges. Only for $r^*<40$ (the separation r is made non-dimensional by the Kolmogorov flow scale), the cross-correlation data depart from the expected behaviours.

It was a common practice in HWA and LDA past investigations to perform data acquisition at relatively low data rate for long time intervals (in comparison to the flow integral scales) when computing single-point statistics. On the other hand, the highest possible data rate for relatively short time intervals was attained for multi-point statistics related to correlation and spectral functions. The results of the present study involving cross-correlation and high-speed PIV systems confirms that this practice is still valid even for data obtained by PIV. The present data also show that for all tested quantities (statistics of velocity, velocity derivative and multi-point statistics) the results obtained with one or the other system are substantially equivalent, providing that the statistical ensemble is built up properly.

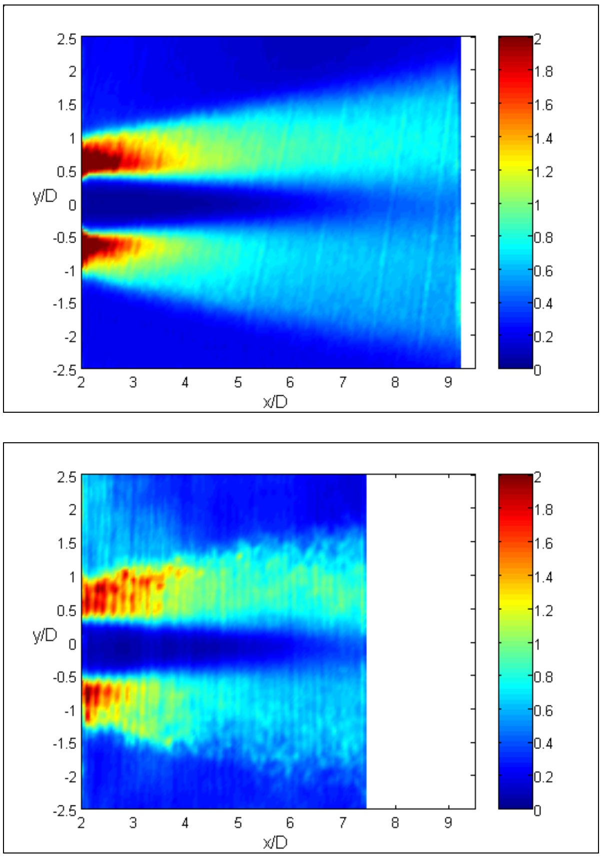

Fig. 1 Non-dimensional isotropic form of turbulent kinetic energy dissipation, $\varepsilon_{iso}D/U^3$, for cross-correlation (at thetop) and high-speed systems (at the bottom) in the near jet.

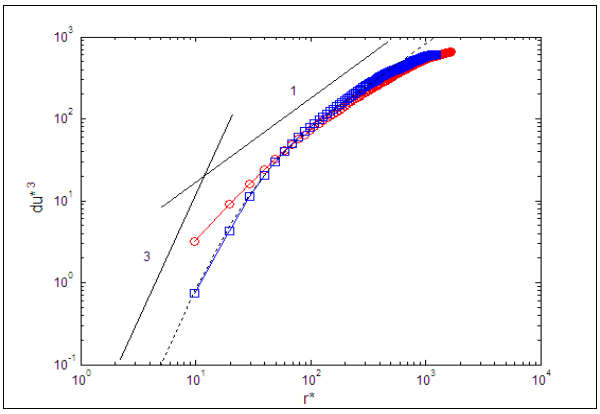

Fig. 2 Third-order structure functions of axial velocity for cross-correlation (in red) and high-speed (in blue) systems in the jet far field. The dotted line is a fit to data.