A 'comprehensive' LDV system for fully-resolved measurements of the instantaneous vorticity and dissipation tensors and the Reynolds averaged velocity-pressure gradient fluctuation tensor in turbulent flows

K. T. Lowe
R. L. Simpson

Dept. Of Aerospace and Ocean Engineering
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061

Abstract

An advanced LDV measurement system taking advantage of some recently introduced techniques for estimating particle crossing position and acceleration in LDV measurement volumes is developed (Czarske et al. 2002; Lehmann et al. 2002). The 'comprehensive LDV' (CompLDV) has been designed to measure instantaneous gradients of velocity, particle acceleration, and all related correlations on the Kolmogorov scales for laboratory flows in the Virginia Tech boundary layer research wind tunnels. This is achieved by very accurately measuring the position, velocity, and acceleration of four particles which occupy the measurement volume over a time window less than the Kolmogorov time scale. These measurements are of great importance for improving Reynolds stress transport models, since no fully-resolved measurements for the dissipation and velocity-pressure gradient fluctuation tensors exist in high Reynolds number turbulent flows.

In this paper, the operating principles and design aspects of the CompLDV are discussed. Since most design aspects were driven by uncertainties, a basic uncertainty analysis for primary measurements is presented. Calibration results in a uniform flow for the fringe spacing versus measurement volume location are also presented. Preliminary results from measurements in the validation flow case: a 2D zero-pressure gradient turbulent boundary layer, $\mathrm{Re}_q \approx 7600$, are discussed.

Czarske, J., Büttner, L., and Razik, T. 2002, "Boundary layer velocity measurements by a laser Doppler profile sensor with micrometre spatial resolution" *Measurement Science and Technology* 13, 1979-1989.

Lehmann, B., Nobach, H., and Tropea, C. 2002, "Measurement of Acceleration Using the Laser Doppler Technique," *Measurement Science and Technology* 13, 1367-1381.