3-D flow imaging using a MHz rate pulse burst LASER system

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Keywords: 3-D Flow Visualization, High-Repetition Rate Imaging, Pulse Burst Laser Systems, Jets, Boundary Layers

Over the past decade significant strides have been made in the development of pulse burst laser systems capable of producing high energy laser pulses at repetition rates in excess of 1 MHz. These unique laser systems are currently being used in experiments across a variety of fields ranging from traditional fluid dynamics to combustion to plasma physics. Described here is the use of one such system for 3-D flow visualization whereby a high-repetition rate laser sheet is scanned through the flow field using a galvanometric scanning mirror and flow images are acquired using a high-speed camera. 3-D images are then reconstructed from the resulting stack of 2-D images. Using existing instrumentation, images with 220 x 220 x 68 pixel resolution can be acquired in 136 microseconds with the primary limitation being the speed and resolution of an available high-speed camera. The strength of the technique is illustrated through 3-D flow visualization experiments conducted in a turbulent jet (Figs. 1 and 2) and a turbulent boundary layer (Fig. 3). 3-D smoke visualization images of the near-field of a turbulent jet depict the complex 3-D interaction between ring vortices and streamwise vortices that form in axisymmetric shear layer of the jet. Turbulent boundary layer images show the 3-D nature of large-scale structures present in the outer layer of the boundary layer and lay the ground work for more detailed future experiments.

Fig. 1 3-D flow visualization image of an axisymmetric jet with Re=9,500. Image has resolution of 312 x 260 x100 pixels and was acquired in 100 µsec.

Fig. 2 Exploded assembly view showing several cross-sections of a turbulent jet with Re=6,800.

Fig. 3 3-D flow visualization image of a turbulent boundary layer with Re\textsubscript{0} = 2,500