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Direct Estimation of Particle Image Velocimetry Measurement Uncertainty from Cross-Correlation Plane Moments ZHENYU XUE, Mechanical Engineering, Virginia Tech, USA, SAYANTAN BHATTACHARYA, Mechanical Engineering, Purdue University, USA, JOHN CHARONKO, Physics Division, Los Alamos National Laboratory, USA, PAVLOS VLACHOS, Mechanical Engineering, Purdue University, USA — Particle Image Velocimetry is a non-invasive measurement technique in which images of flow tracers are correlated to estimate flow velocity. The coupled effect of error sources including particle image size, velocity gradient, out of plane motion, and seeding density poses a challenge in quantifying the uncertainty. Here we establish a method to quantify PIV uncertainty by extracting the Probability Density Function (PDF) of all possible displacements from the cross-correlation plane. The PDF is obtained by deconvolving particle image size from the correlation plane, and approximating its shape and standard deviation by an elliptic Gaussian least squares fit. The PDF variance is then scaled by a normalized estimate of the number of correlated particles between the image pairs to obtain the standard uncertainty. The method takes into account the peak stretching due to velocity gradients and also includes an estimate of bias error. The calculated uncertainty is compared with the RMS error for synthetic and experimental images, including a vortex ring and the recent uncertainty benchmark jet flow cases. Results show reasonable uncertainty coverage. Thus, the current framework provides a direct approach to quantify PIV uncertainty from the correlation plane.

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