Deconvolution of the turbulent interface profile measured by PIV

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Thin layers are commonly observed on the edges bounding a turbulent flow region (Hunt et al. 2011). Examples include the edge of a cloud and the turbulent/non-turbulent interface bounding a jet (Westerweel et al. 2009). The interfaces are dynamically significant as they control the entrainment of fluid into the jet via a small-scale nibbling process. Additional interest in interfaces, or more specifically shear layers, emerges from the observation that they appear to be associated with the universality of the small-scales in turbulent flows (Elsinga and Marusic 2010).

Particle Image Velocimetry (PIV) would seem ideally suited to investigate experimentally the spatial structure of such interfaces, as well as their interaction with the surrounding larger scale turbulent motions. However, the spatial resolution of PIV is often insufficient to do so.

In this paper we revisit the thickness of the jump in the velocity gradient across the turbulent/non-turbulent interface of a jet and determine it with improved accuracy (figure 1). The effect of the finite size correlation window on the measured velocity profiles across the interface is mitigated by a deconvolution of these profiles with the correlation method’s point-spread-function (Elsinga and Westerweel 2011). Furthermore, the deconvolution approach is assessed based on simulated PIV experiments on random particle displacement fields of different coherence lengths.

Fig. 1 The particle displacement gradient across the interface determined using window deformation and different window sizes (solid lines). Additionally, a Gaussian window weighting method has been used (purple line). The corresponding deconvoluted profiles are indicated by the symbols. These are bounded by the gray solid lines, which collapse well for the jump that is located between \( y_i = -10 \) pixel and +14 pixels (width 24 pixels, compared to 32 pixels before in Westerweel et al. 2009). The presented displacement gradient is indicative of vorticity across the layer.

References


