Experimental detection of large-scale flow structures in a Rayleigh–Taylor instability

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Here we present an experimental examination of large-scale structures in Rayleigh–Taylor instability (RTI). Following previous theoretical[1] and numerical[2] studies we find experimentally that large-scale structures are continuous and persistent across the mixing layer (figure 1). Our experimental set up[3,4] is comprised of two layers of fluid separated by a polycarbonate barrier, at $z = 0$, in an acrylic tank. A statically unstable stratification is set up across the barrier such that when the barrier is removed RTI develops (figure 2). Velocity and density data are collected using particle image velocimetry and planar laser induced fluorescence. Large-scale structures are found using a Lagrangian-filtering based technique[2], which allows us to divide the flow into two structure fields b^+ (downward moving) and b^- (upward moving). The experimentally determined $b^\pm$ fields show reasonable agreement with previous theoretical/numerical work. Finally, we present the results of an examination of the $b^\pm$ fields with other structure detection methods such as rortex–shear decomposition and finite-time Lyapunov exponents.

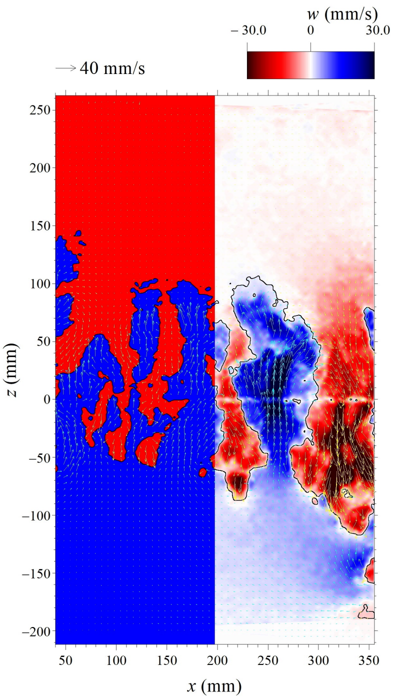

Figure 1: Left shows structure fields and right shows w-component of velocity.

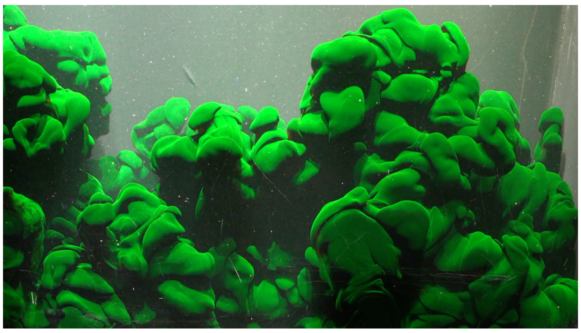

Figure 2: Qualitative three dimensional visualisation of large-scale structures.

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[1]LLor, *Statistical Hydrodynamic Models for Developed Mixing Instability Flows*, Springer (2005).

[2]Watteaux et al., *In preparation* (2023).

[3]Linden and Redondo, *Phys. Fluids A* **3** 5 (1991).

[4]Dalziel et al., *J. Fluid Mech.* **399** (1999).