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Experiments on bubble breakup in homogeneous isotropic turbulence: correlating local interface dynamics and surrounding flow structures

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The breakup of bubbles in turbulent flows is a fundamental phenomenon with wide-ranging applications in environmental sciences, industrial processes, and fluid dynamics research. Despite extensive studies, open questions remain regarding the mechanisms that govern the interface evolution leading to breakup and the local correlation between interface deformation and surrounding flow structures. In this work, we use five high-speed cameras to reconstruct the three-dimensional interface of air bubbles dispersed in homogeneous isotropic turbulence. These reconstructions are coupled with velocity measurements from 3D Particle Tracking Velocimetry (Shake-The-Box), which are then converted into an Eulerian velocity field via the Vortex-In-Cell (VIC+) technique. This approach enables us to resolve sub-bubble-scale eddies and compare their spatial and temporal scales with those of the deforming interface. As a result, we correlate local deformation with turbulent flow structures across multiple scales, isolate turbulence-induced breakup events from those governed by capillarity, and identify the main mechanisms driving the breakup.

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