Statistical Characterization of Helium-Filled Soap Bubbles Tracing Fidelity for PIV

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HIGHLIGHTS

- When the bubble generators operate in a stable production regime, variations of the bubble diameter below 5% are observed.
- For neutrally buoyant bubbles, the mean value and the standard deviation of the bubble relaxation time are of the order of 10 µs and exceeding 30 µs respectively.
- When the bubbles’ production regime is unstable, the standard deviation of the bubble diameter and relaxation time can be as high as 70 µm and 50 µs, respectively.
- HFSBs allow accurate measurements of the time-averaged velocity field. Conversely, caution should be taken concerning the accuracy of the instantaneous and fluctuating flow properties due to the spread of the bubbles’ relaxation time.

ABSTRACT

The present work follows a previous study on the aerodynamic characterization of helium-filled soap bubbles (HFSB) for large-scale PIV measurements. HFSB were found to yield, on average, a time response of about 1 µs. However, the response of each individual tracer remained to be ascertained, which is the topic of the present study. The velocity of the bubbles in the stagnation region ahead of a circular cylinder is evaluated by the PTV technique. The results are compared with micron-size fog droplets taken as reference. The tracking error of individual trajectories is assessed by statistical analysis of the relative slip between the bubble and the airflow. The instantaneous particle relaxation time is retrieved from the ratio between slip velocity and local acceleration. Additional information on the bubble instantaneous properties is taken by inferring the diameter from the distance between the glare points. The results are discussed and related to the differences observed in the bubbling and jetting regimes for bubble production. Finally, the HFSB relative density to the air is estimated using a modified Stokes drag law.

Fig. 1 Slip velocity (left) and relaxation time (right) individual bubbles on the stagnation line of the cylinder for neutrally buoyant helium-filled soap bubbles.