TIME-RESOLVED BACKLIT PIV MEASUREMENTS OF A 2-PHASE FLOW (BUBBLES AND MEDIA)

APPLICATION NOTE TRPIV-005 (A4)

Two-Phase Flows (Bubbles in Water)

A wide variety of applications in fluid mechanics require the velocity measurement on multiple phases. Examples of this could include the separation of crude oil from water, cavitation, and sediment transport. In these cases, it is desirable to measure the velocity of both phases and media. The following application shows the measurement of an air-water system, where the velocity of both the air bubbles and the continuous phase of water are of interest.

Experimental Setup

The time-resolved PIV system consisted of a dual-head 1000 Hz Nd:YLF pulsed laser (TSI Model# YLF10-1000-LIT) with 30 mJ/pulse and fitted with adjustable light sheet optics (Model# 610026), and a 1280 × 800 pixel CMOS camera operating at 1000 Hz (Model# 630083-3GB) as seen in Figure 1.

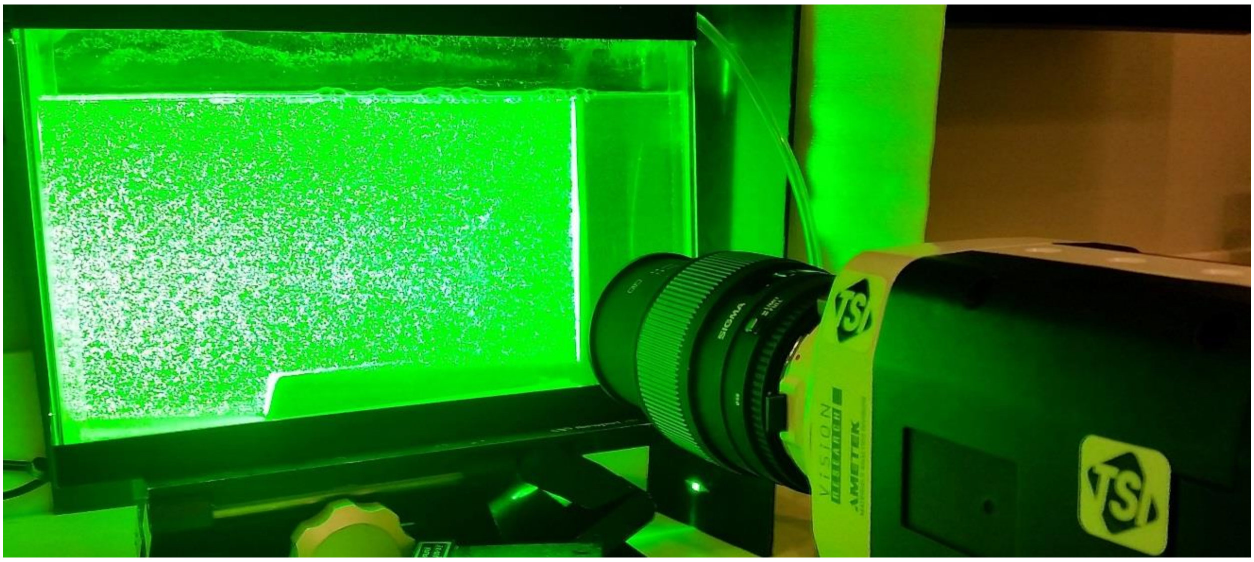

Figure 1. Image of the experimental setup.

The laser was positioned so that the light beam was diverged to form a large background illumination on a diffuser placed at the background of the bubbly flow chamber. The camera was positioned on the opposite end of the flow chamber with its axis collinear with the laser illumination with a 135-mm lens set at f#2.8. A sparger was positioned at the bottom of the flow chamber, and bubbles of approximate size 1–2 mm were formed and were drawn upward through buoyancy forces. In addition to the bubbles, the flow was seeded with 12-micron hollow glass spheres to be used as the tracer particles for the continuous (water) phase.

Image Processing

The image pre-processing was done using INSIGHT 4G™ software. Dynamic Background Subtraction (DBS) and Particle of Interest Enhancement (PIE) were used to produce two separate images from each raw image. Each of the new images contained information related to different phases, the bubbles and the tracers.

An example image can be seen below, with the two subsequently created images shown on the right highlighting the effectiveness of the technique in extracting relevant information.

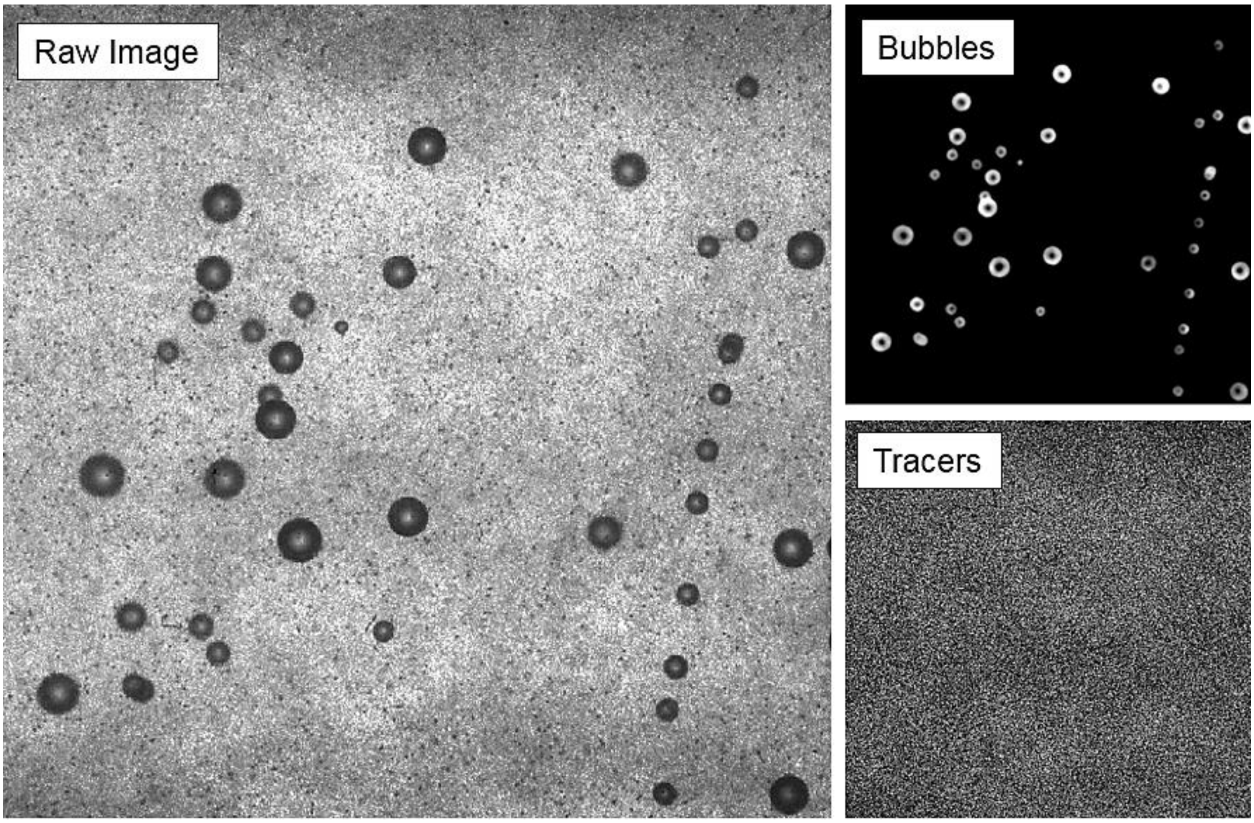

Figure 2. Image pre-processing steps. A raw image is shown on the left, and the pre-processed images showing the gas-phase (bubbles) and the continuous phase (tracers), are shown on the right.

When volume illumination is used for two-dimensional velocity measurements, as in this case (or in microPIV), the depth of focus defines the measurement depth. For this reason, the image pre-processing parameters and identification threshold values used must respect the optical setup in order to properly match the thickness of the depth between the two phases. Size-Shape Analysis (SSA) was performed on the gas phase and the Particle Image Velocimetry (PIV) was performed on the continuous phase.

Results

The results of the gas-phase sizing and tracking can be seen in Figure 3. Larger bubbles (up to approximately 1.5-mm) are shown in red. Smaller bubbles are shown in green and blue. The paths indicating the bubble buoyancy are clearly visible in the tracks.

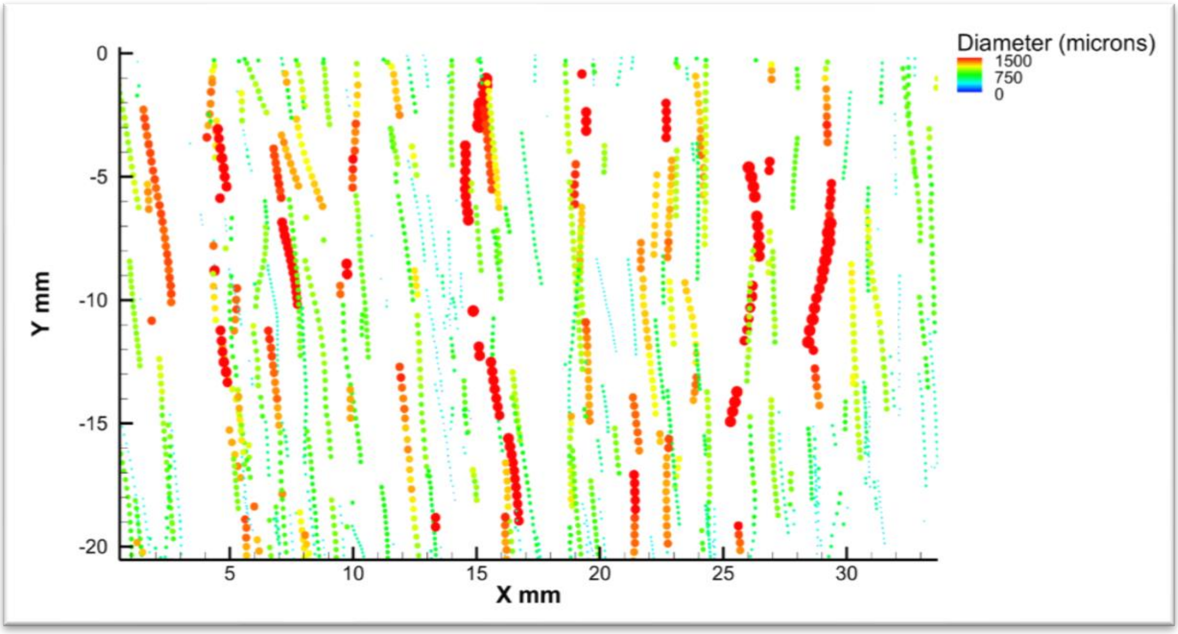

Figure 3. Bubble tracks over a series of captures. Coloring indicates diameter, as shown.

In addition to the gaseous phase, the continuous phase was analyzed using the PIV processing in INSIGHT 4G™ software. A single snapshot is shown in Figure 4 displaying the vertical velocity contour of the continuous phase, with the bubbles with velocity vectors overlaid.

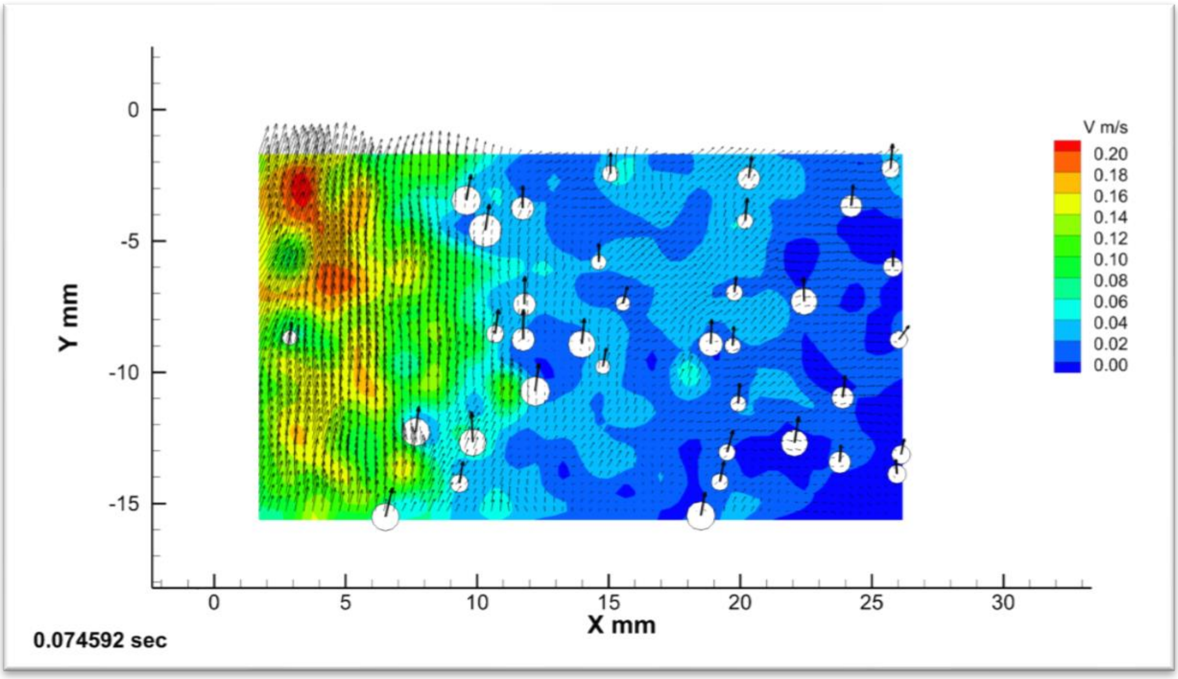

Figure 4. An instantaneous velocity field showing both the velocity of the continuous phase (contour with vectors) and the gas phase (shown in white with corresponding vectors).

Conclusion

An experiment was conducted with a single camera to simultaneously capture the velocity of a multiphase flow. Gas bubbles in water were tracked through time while the velocity of the water was also determined. Image capture, pre-processing, and data processing were performed in INSIGHT 4G™ software.

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