Three-dimensional simultaneous measurements of a rising microbubble position and flow surrounding the microbubble by a digital hologram

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Three-dimensional simultaneous measurements of the position of a rising microbubble, and of the velocity field surrounding it, are performed by micro-digital holographic velocimetry. The rising position of the microbubble and the many particles surrounding the microbubble can be reconstructed by a digital hologram. This technique has successfully been applied to the 3-D dynamics of a hydrogen microbubble, in a vertical water channel, that emanates from a platinum electrode by electrolysis. The velocity of the microbubble and the flow of particles surrounding the microbubble are simultaneously obtained.

Figure 1 is a schematic of the experimental setup that shows the location of a laser beam from one single source. In this experiment, A Nd:YLF laser (λ= 527 nm) was used as a light source out-putting a pair of laser pulses at a repetition rate of 1 kHz, and a pulse delay of 100 μsec. The laser beam was expanded to illuminate the center of a test section. The test section (height = 62 mm, width = 24 mm, and depth = 10 mm) shown in Fig. 1, was made of glass. For this test 40-micron nylon spherical particles were used. The working fluid was a 0.2% NaCl solution in water. In this work, the hologram fringe images were captured through a high-resolution digital CCD camera (IDT NR5S2) without a lens with a resolution of 2336 x 1728 (7 μm / pixel), that captured the images at 1 kHz, and used 1024 x 1024 pixels in the full imaging area. The camera and the laser were synchronized by a pulse generator, and the exposure time was set to 100 μs. The system was design to work with 800 frames using the camera memory with a sampling rate of 1 kHz. Microbubbles with spherical shapes were generated by a potentiostat built into a platinum electrode. The voltage was set at 3.1V. The microbubble that is shown above the platinum electrode is made by digital reconstruction [1]. The diameter of the micro bubble remained approximately within the neighborhood of 140 μm. The reconstructed volume is 8 x 8 x 10 mm³. Almost all particles are uniformly distributed surrounding the microbubble. It can be seen that starting from the bottom the flow is upstream; and that the velocity of the microbubble can be obtained from the two images and found to be approximately 10 mm/sec. The seeding particles on the images do not dramatically change because their flow speed is slower than that of the microbubble. The obtained instantaneous 3-D velocity vectors from the three visual perspectives are shown in Fig. 2, although we photographed the time evolution of these vectors for 0.8 second (not shown). It can be seen that the flow is moving upward, and the quick flow arises especially in the upper part of the microbubble. This is a flow which is made the rising microbubble and it arises. Moreover, the vector distribution around the rising bubble is higher than in any other domain. The reason is the flow induced by the rising bubble only exists. This is because only the existence of the rising bubble causes the flow. The instantaneous velocity vectors on the images do not drastically change because the flow speed is relatively slow.

Figure 2 Vectors of a rising microbubble and particles between t = 279msec and t = 379msec

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References