High-speed ILIDS measurement of evaporating droplet

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Abstract

In order to investigate the dynamic interaction between liquid and gas phases in such multiphase flows as spray and bubbly flows, the size and momentum of individual particle are the significant quantities. Moreover the improvement of multi-dimensional and spatio-temporal spray measurement technique leads us to investigate the detailed heat and mass transport phenomena, and to construct the practical computation models for numerical simulations. Interferometric laser imaging for droplet sizing (ILIDS) technique was firstly developed for the investigation of the instantaneous spatial distribution of droplet size by means of laser light source and film imaging methodology. Sizing equation was derived by considering the optical pass difference of the scattered lights from a droplet by the geometric optical approximation. Although the difficulty in discriminating the overlapped parallel fringes in the captured image was overcome by optical squeezing technique, temporal resolution was still low due to the limitation of the imaging facility. In the last decade, the drastic improvement of optical matrix sensor such as CCD or CMOS camera enables the dynamic measurement of flow field whose sampling frequency is over several kHz with simultaneous exposure of each pixel. Another contribution is due to the light source. Nd:YLF laser could emit the coherent light with high repetition frequency. In the present study, the single-cavity double-pulsed laser system was employed in conjunction with the synchronized high-speed camera. The relation between droplet size and fringe frequency was numerically investigated to estimate the measurement error due to the non-linear relation between them. Moreover the effect of laser sheet thickness, and of refractive index fluctuation was analyzed. The size transition of the droplets within a few milliseconds was experimentally investigated. The results led us to evaluate the mass transfer rate at the gas-liquid interface of the individual droplet.

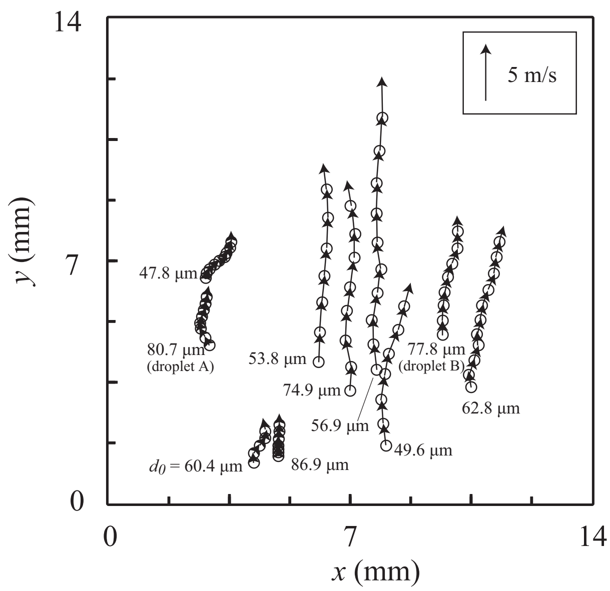

Figure 1. Measured particle trajectories by particle tracking. Hollow circles and corresponding arrows represent the instantaneous droplet locations and the individual velocity vector respectively. Frame rate of the image acquisition is 4000 Hz, consequently the temporal resolution of the droplet sizing and velocimetry is 0.25 ms. Initial droplet diameters are depicted in the vicinity of the initial droplet locations.

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