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A PIV/PTV system for analysing turbulent bubbly flows

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ABSTRACT

Bubble columns are widely used in chemical industry and biotechnology. Flow and turbulence in such an apparatus are induced by the bubble rise, and the bubble behaviour is strongly affected by swarm effects (i.e. the interaction between bubbles). For analysing the bubble swarm behaviour and simultaneously evaluating the flow structure and bubble-induced turbulence in a bubble column of 140 mm diameter and a height of 650 mm (initial water level) Particle Image Velocimetry (PIV) was applied. The bubble column was aerated with relatively fine bubbles with a size distribution between about 0.3 and 4.0 mm. The gas hold-up was varied in the range between 0.5 and 4 %.

A two-phase PIV-system was developed to evaluate instantaneous flow fields of both rising bubbles and the continuous phase (Fig. 1). The measurement of the liquid velocities in the bubble swarm was done by adding fluorescing seed particles. Images of bubbles and fluorescing tracer particles were acquired by two CCD cameras. The signals from tracers and bubbles were separated by optical interference filters with a band width corresponding to the emitting wavelength of the fluorescing tracer particles and the wavelengths of the applied Nd-YAG pulsed laser. To improve the phase separation of the system the CCD cameras were placed in a non-perpendicular arrangement with respect to the light sheet.

The acquired images were evaluated with a cross-correlation algorithm developed by Gui et al. (1997). In order to obtain information about bubble motion and the local velocity of the fluid 500 to 1000 image pairs were recorded and evaluated. By averaging the instantaneous velocities of bubbles and fluid, mean velocities and fluctuating components could be obtained. In addition turbulence intensities were deduced from the measurements. The turbulence properties were used to characterise bubble-induced turbulence for various bubble mean diameters and gas hold-ups. Moreover, the determination of the average bubble slip velocity within the bubble swarm was possible.

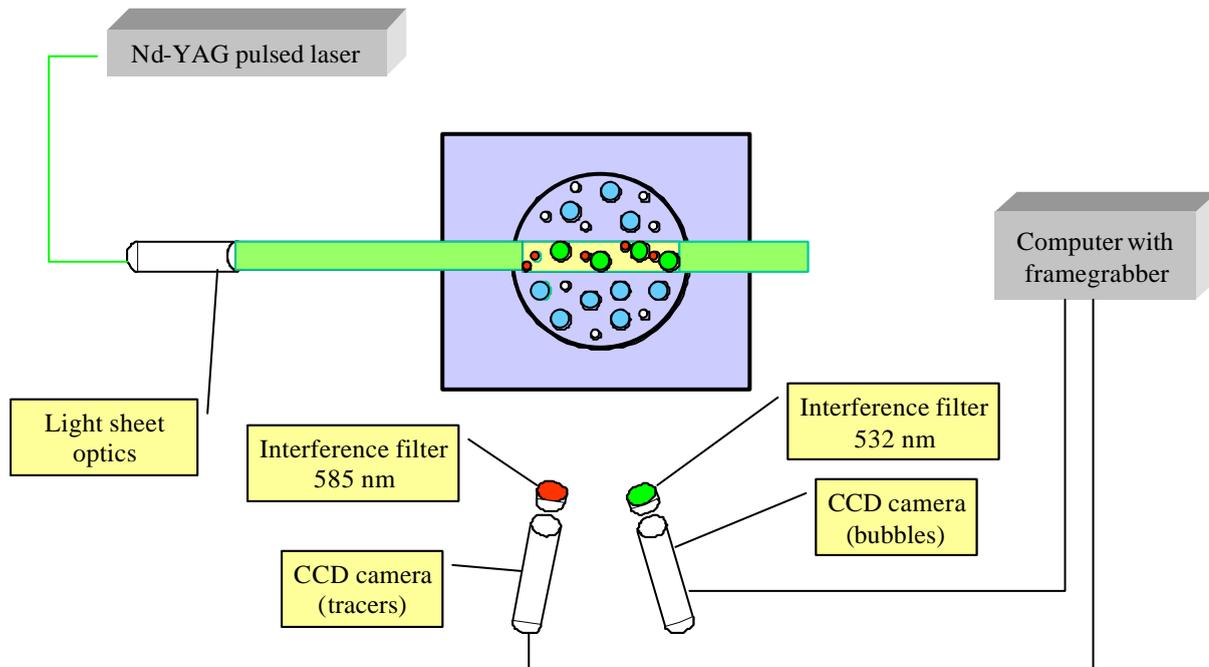


Figure 1: Two-phase PIV-system