Time-resolved measurements of the free surface motion due to spinning micro-rafts using Stereo MicroPIV

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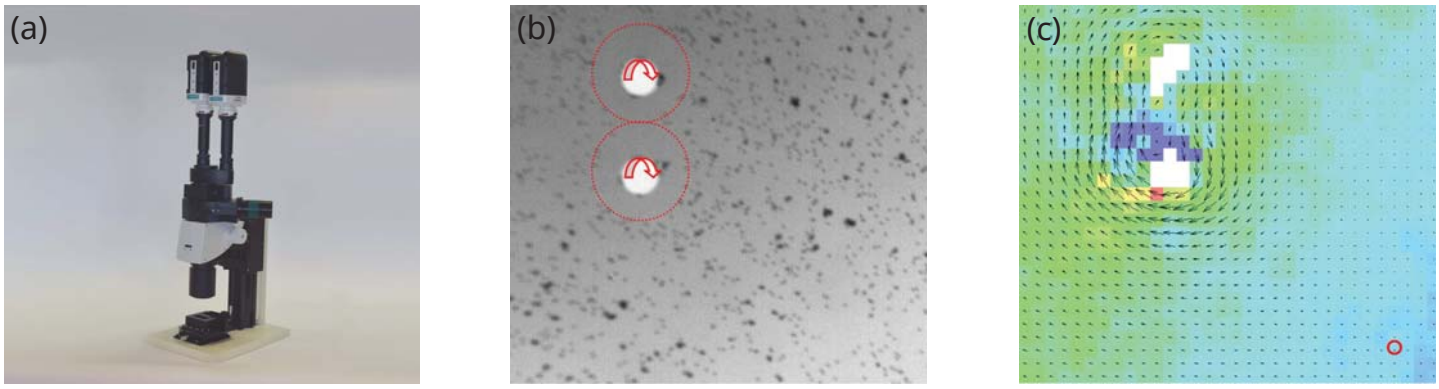


Figure 1 (a) Time-resolved Stereo μPIV system shown with the image calibration kit **(b)** Typical raw particle image of the spinning micro-rafts. Red arrows indicate the rotation direction; red dashed circles boundary for low seeding **(c)** Stereo μPIV results at the same time instant where colors indicate out of plane velocity component. Red circle is where the time series is extracted in Fig. 2

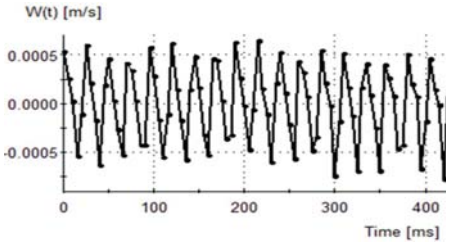
Introduction

Time-resolved Stereo MicroPIV system (Fig. 1a) is used to measure the free surface motion created due to a pair of spinning micro-rafts [1]. The 100 μm-diameter cylindrical magnetic rafts were spun in the clockwise direction with a spin rate of 2500 rpm using an external magnetic mixer. The three-dimensional (3D) motion of the free water surface was measured by tracking 5 μm-fluorescent seeding particles.

Interestingly, some of the seeding particles coagulated on the rafts' sidewalls, acting as micro-vanes. In the vicinity of the micro-rafts, large seeding particles were pushed away from the micro-rafts due to the centrifugal effect and a low seeding concentration region was formed (Fig. 1b).

Post-processing

Dynamic masking was performed to remove both rafts from the raw images, which increased accuracy during two-component (2C) PIV analysis before stereoscopic reconstruction. The stereo image calibration was performed at 16.6x magnification, using a 900 μm-wide, square checkerboard calibration target. A calibration refinement process followed to correct for severe camera misalignment between calibration and experiments. Spurious vectors were replaced using a Universal Outlier Detection scheme.



Results

The spinning micro-raft pair produced a distinct, 8-shaped vector field rotating around itself in the clockwise direction at a constant speed (Fig. 1c). Since the rafts were spun in the same rotation direction, a severe shear layer formed between them, and this produced most spurious vectors. The flow disturbances created by the spinning microrafts produced a periodic sloshing motion in the far field (Fig. 2). The frequency of the out-of-plane velocity component is measured as ~42 Hz, which is in perfect agreement with the excitation frequency (2500 rpm).

Figure 2 Time series of the out of plane velocity component at the red circle in Fig. 1c

REFERENCES
[1] Wang W, Giltinan J, Zakharchenko S and Sitti M "Dynamic and Programmable Self-assembly of Micro-rafts at Air-water Interface", submitted.