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

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ABSTRACT

Time-resolved Stereo MicroPIV experiments were performed to measure the free surface motion created due to a pair of spinning micro-rafts [1]. The 100µm-diameter cylindrical magnetic rafts were spun in the clockwise direction with a spin rate of 2500rpm using an external magnetic mixer (Fig.1a). 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. 1a). 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 900µm-wide, square checkerboard calibration target. A calibration refinement process followed to correct for severe camera misalignment between calibration and experiments. Since the rafts were spun in the same rotation direction, a severe shear layer formed between them, where most spurious vectors were computed. These were replaced using a Universal Outlier Detection scheme. The spinning micro-raft pair produced a distinct, 8-shaped vector field rotating around itself in the clockwise direction at a constant speed (Fig. 1b). 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.

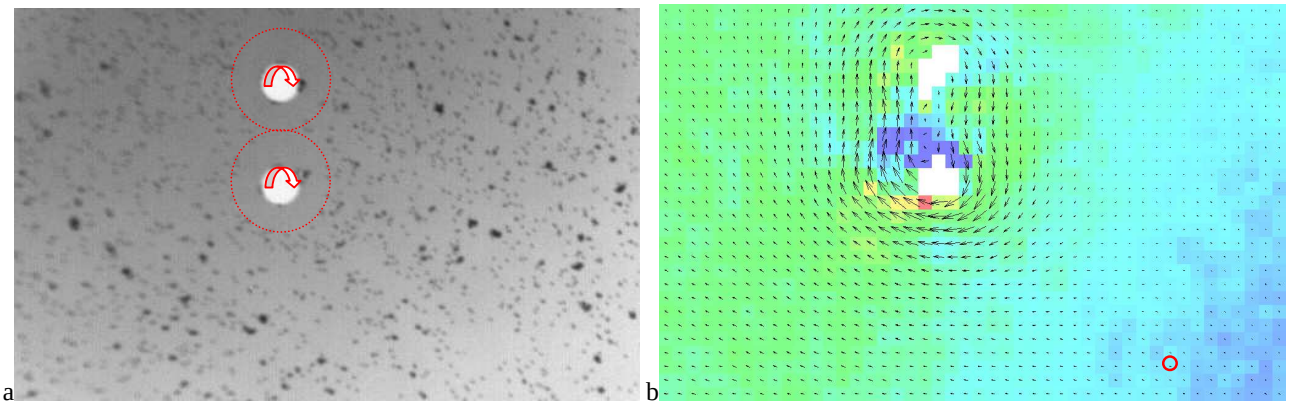

Figure 1 (a) Typical raw particle image of the spinning micro-rafts at t=130ms. Red arrows indicate the rotation direction; red dashed circles show the boundary for low seeding concentration (b) Stereoscopic PIV results at the same time instant where colors indicate out of plane velocity component. Red circle is where the time series is extracted in Fig. 2.

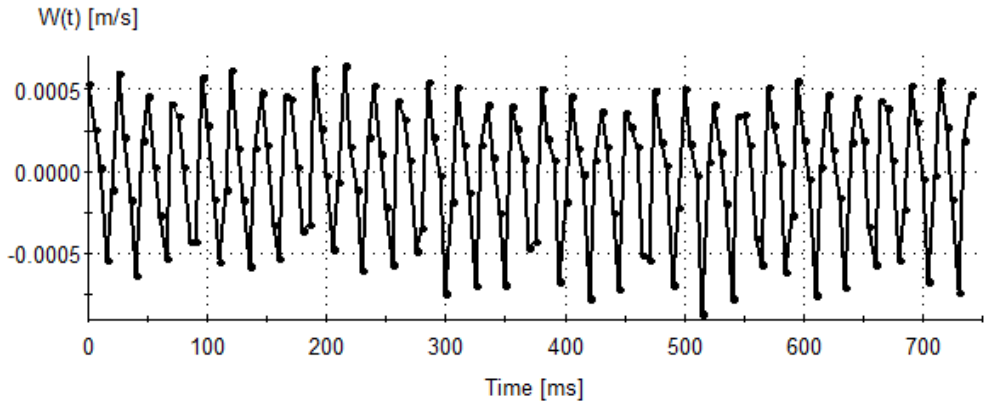

Figure 2 Time series of the out of plane velocity component at the red circle in Fig. 1b.

REFERENCES

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