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Stereoscopic PIV adapted to gravity wave analysis

by

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ABSTRACT

Intrusive techniques of measuring the orbital velocities underneath gravity disturb the flow field in every case. Consequently, merely non-intrusive techniques can be applied to get information about the kinetics of the wave boundary layer, about the correlation between wind stresses and generated velocity profiles beneath the water surface, about the interaction of wave induced flow fields with oscillating water column energy converters and about wave energy transmission around permeable breakwaters.

A state-of-the-art stereoscopic particle image velocimeter was adapted to the wave flume of the University of Leipzig where the flow field is optically accessible from every point of view. The PIV set-up is based on the Scheimpflug principal recording images with the image sensor in the plane of best focus even when the object plane is not parallel to the lens principal plane. In this way, it is possible to rotate the image sensor into the plane of best focus without moving the camera objective itself. Keeping the camera view to the double-pulsed laser light sheet from an off-axis angle the Scheimpflug arrangement allows continuing the plane of best focus in the plane of the double-pulsed laser light sheet. Particularly for investigations underneath long-crested waves the Scheimpflug arrangement was found to be the best layout for stereoscopic PIV not only because of its ability to align the plane of best image but regarding to focal distances and camera angles. To reduce sub-pixel bias errors and to eliminate spurious vectors resulting from unmatched particle pairs, out-of-boundary motion, particle overlap, inter-particle correlations and optical imaging noise a non-post-interrogation method is used as correction technique which improves spatial resolution and vector yields.

Results obtained by the adapted stereoscopic PIV are presented for wave-structure interactions of monochromatic waves and a semi-submerged vertical wall, wave-structure interactions of regular waves propagating oblique towards a submerged horizontal plate and a breaking wave occurring due to the superposition of numerous wave components of a real sea state.

After the adaptation of the stereoscopic PIV-system to the specific conditions in a wave flume, it is now possible to map the flow conditions beneath gravity waves very sufficiently. It is possible to record wave-structure interactions very easily and rapidly by physical modelling. Time history velocity fields can be recorded and presented as three-dimensional velocity maps. The PIV system allows to investigate wave-induced motion in the vicinity of coastal structures in order to get information about turbulence parameters and wave energy dissipation as well as their distributions both locally and in time. Furthermore, complex wave motion can be investigated by observing and capturing the particular flow phenomena in a wave flume, e.g. real sea states consisting of numerous components superposing or decaying.