Experiments on kinematics of deep-water breaking waves

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Breaking is the dominant factor causing wave energy damping, nevertheless, in spite of extensive studies the mechanisms leading to breaking are not yet fully understood. The lack of comprehensive information about the breaking process can be attributed to the complexity and rapidness of the phenomenon. The present experiments were motivated by our theoretical study based on the Zakharov equation in which the contribution of higher order bound waves to the kinematics of extremely steep waves of wide spectra was considered. These results suggest that the dynamic criterion for wave breaking originally suggested by Phillips (the maximum negative value of the vertical acceleration at the free surface does not exceed g) cannot be satisfied. Numerical simulations indicated that the inception of breaking may be attributed to the local horizontal velocity of water at the crest that may exceed crest propagation velocity. It was also found that for a wider spectrum, crest propagation velocity differs from both the phase and the group velocities of the dominant wave.

A group with a single breaking wave at a prescribed location in an 18 m long wave tank was by excited by a programmable wavemaker. The group chosen is a Peregrine soliton-type wave train with a dominant period of 0.8 s. Two identical synchronized Canon D7 cameras operating at 60 fps at resolution of 2 Mpixel were used. The velocity field in the vicinity of the breaking location was studied using Particle Tracking Velocimetry by a camera looking at the wave field from above. Buoyant particles with diameter of about 3 mm were used as tracers to study the variation of the instantaneous surface velocity at various locations relative to the breaking wave's crest. The instantaneous surface elevation was measured from the records taken by the 2nd camera that captured the contact line shape variation at the side wall of the tank, thus providing data on the instantaneous surface elevation in the whole field of view. These records were also used to determine the instantaneous crest location, velocity and acceleration. Results on the actual crest movement and shape at different stages of the breaking process will be presented and compared with the instantaneous horizontal water velocities and accelerations.