WAVE BLOCKING AND SMALL-SCALE BREAKING ON AN OPPOSING CURRENT

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Blocking of surface water waves by strong opposing currents is one of intriguing phenomena in wave-current interactions. Around the location where waves are blocked, i.e., blocking point, waves experience drastic changes in the wave length and amplitude with rapid shortening, steepening, and decaying due to blocking or/and breaking. Understanding of the wave climate around the blocking point has great significance in modeling ocean wave evolution, interpreting remote sensing data, and predicting navigation hazards. In this study, the effects of spectral bandwidth and nonlinearity on wave blocking or/and breaking processes are examined. Well-controlled laboratory experiments on varying amplitudes of monochromatic, narrow-banded, and broad-banded waves on strong spatially varying opposing currents achieved by a raised bottom were conducted. Results of measured surface displacements, wave profiles and velocity fields in the vicinity of the blocking point are reported.

For narrow-banded or monochromatic waves of lower incident amplitudes, around the blocking region the waves became shorter and reflected waves formed a long tails in the time series of the surface displacement. The gradual frequency downshift was also observed. Beyond the region of blocking point, no wave energy was propagated through and the wave packets were fully blocked. The spatial wave profile showed that a series of short capillary waves at the front of the blocked wave appeared and the amplitude of capillary waves significantly decreased due to viscous damping. With increasing amplitude of incident waves, the reflected waves became higher and pushed the blocking point further downstream, indicating the importance of wave nonlinearity. The enhanced frequency downshift was observed. In contrast to the lower amplitude case, the wave profile was replaced by a short wave with parasitic capillary waves riding on the forward face of the crest. The growth and the relative motion of the parasitic capillary waves on the underlying crest led to a so called micro-scale breaking during the wave blocking process. Finally a lower frequency wave packet was found to escape from the blocking region and propagated through. For broad-banded waves with lower amplitude on strong opposing currents, the high frequency waves were blocked while low frequency components were not, leading to so-called partial blocking [1]. The features of the blocked high frequency waves were similar to those of narrow-banded waves. With increasing amplitude of incident waves, a spilling breaker occurred and followed with a series of short capillary waves at the front of the blocked wave. Interestingly, no frequency downshifting was observed.

References

[1] A. Yao and C.H. Wu, "Energy dissipation of unsteady wave breaking on currents," *J. Physical Oceanography*, 34, N10, 2288-2304, 2004.

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