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Laboratory tests of short intense envelope solitons

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Stability of short intense nonlinear wave groups propagating over deep water is tested in laboratory runs which are performed in the facility of the Technical University of Berlin.

The strongly nonlinear simulation of quasi-steady nonlinear wave groups within the framework of the Euler equations is used to generate the surface elevation time series at a border of the water tank. Besides, the exact analytic solution of the nonlinear Schrodinger equation is used for this purpose. The time series is then transformed to a wave maker signal with use of a designed transfer algorithm. Wave group propagation along the tank was recorded by 4 distant gauges and by an array of 6 densely situated gauges. This setup allows to consider the wave evolution from 10 to 85 m from the wave maker, and to obtain the wave envelope shape directly from the instrumental data.

In the experiments wave groups were characterized by the steepness values up to $kAcr < 0.32$ and $kAtr < 0.24$, where k is the mean wavenumber, Acr is the crest amplitude, and Atr is the trough amplitude; and the maximum local wave slope was up to 0.34. Wave breaking phenomenon was not observed in the experiments.

Different mean wave numbers and wave groups of different intensities were considered. In some cases the wave groups exhibit noticeable radiation in the course of propagation, though the groups are not dispersed fully. The effect of finite water depth is found to be significant on the wave group stability. Intense wave groups have shorter time of adjustment, what in some sense may help them to manifest their individuality clearer.

The experimental tests confirm recent numerical simulations of fully nonlinear equations, where very steep stable single and interacting nonlinear wave groups were reported [1-3]. The quasi-stationary wave groups observed in numerical and laboratory experiments are strongly nonlinear analogues of the nonlinear Schrodinger envelope solitons. The results emphasize the importance of long-living nonlinear wave groups in dynamics of intense sea waves.

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