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Modulation depth and breaking strength for deep-water wave groups.

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Progression of nonlinear wave groups to breaking was studied numerically and experimentally. Evolution of such wave group parameters as distance to breaking and modulation depth was described. The wave modulation depth R is a height ratio of the highest H_h and the lowest H_l waves in the group: $R = H_h/H_l$ (Babanin et al. 2009). This parameter, together with distance to breaking, was studied by means of the fully-nonlinear Chalikov-Sheinin (CS) model (Chalikov and Sheinin, 2005). Subsequent experiment demonstrated a good qualitative agreement with the numerical results. In the present study, both in numerical simulations and laboratory experiments, a wave group was initially generated as a superposition of two waves with primary and secondary wave steepnesses and close wave numbers, and allowed to evolve. It was shown that the modulation depth decreases as a function of the primary wave steepness, that distance to breaking also decreases with primary wave steepness, but grows as a function of the ratio of the primary and secondary wave steepnesses.

Babanin et al (2007) investigated initially monochromatic wave trains, where the side bands necessary for the Benjamin-Feir (BF) modulation (Benjamin and Feir 1967) grew naturally from the background noise. These monochromatic waves experienced self-modulation, and developed into strongly modulated wave groups. In the subsequent study, Babanin et al. (2009) noticed that the depth of this modulation is essentially affected by the wind and, in turn, influences the breaking severity. In the present study, in order to achieve different modulation depths and investigate this connection of wave groups with the breaking strength, but to avoid the complicating action of the wind, the wave groups were initially imposed. It was shown that energy loss, i.e. the breaking severity is a function of modulation depth. Energy loss grows with modulation depth up to a certain level of the latter. It was also found that breaking probability for wave groups with modulation depth R<2.2 is very low, in absence of the wind.

To continue the investigation of distance to breaking and modulation depth numerically, simulations of these parameters in presence of the wind were performed. It was found that distance to breaking decreases with wind forcing, but starts to increase again when the wind becomes very strong. Modulation depth before breaking was shown to be independent of primary wave steepness for very strong winds (for light winds Rdecreases as a function of the primary wave steepness similarly to the no-forcing conditions).

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