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Numerical simulations of irregular wave ensembles affected by variable wind conditions

Alexey Slunyaev (1,2) and Anna Sergeeva (1,2)

(1) Institute of Applied Physics, Nizhny Novgorod, Russia (a.sergeeva@hydro.appl.sci-nnov.ru), (2) Nizhny Novgorod State Technical University, Nizhny Novgorod, Russia

The numerical simulations of irregular wave trains over deep water aim at the solution of the global problem how the wind action affects the sea state in respect of the rogue wave probability associated with the non-gaussianity of the wave statistics. It has been shown that changes of the sea condition of various kinds (winds, currents, etc., see [1-5]) result in the strongly non-stationary 'fast' evolution, when the likelihood of extremely high waves increases greatly. Hence, transitional processes when the momentary Benjamin – Feir index (BFI) restores from a large value to the value of order one are considered in the present work. The departure of the BFI from the stationary value ($\sim$1) is due to the strong wind effect, similar to the study conducted in [1, 2]. In the present work the modified nonlinear Schrodinger equation with a forcing term is employed to simulate the wave dynamics. The modulational instability of a plane wave within this framework was analyzed in [6]. We estimate the rate of the wind impact which is required to destabilize the given sea state, causing larger probability of rogue waves, and compare it with some available observations of the in-situ measurements.

The reported work may be considered as a simplification of the problem of shoaling nonlinear waves, when all depth-dependent coefficients of the evolution equation are put constants, and only the shoaling term causes wave statistics evolution. Irregular surface waves in basins with different water depths were simulated numerically and in a laboratory facility in [7-10]. When waves travel from deep to shallower water, two situations were shown to exist: when the waves experience a high probability of extreme waves, or when the statistical properties do not change noticeably. No conclusive recipe was formulated how to differentiate these two scenarios. Our work helps to tackle that problem.

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