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The method of spectral decomposition into free and bound wave components. Numerical simulations of the 3D sea wave states

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The evolution of spectra of sea surface gravity waves is obtained by virtue of the direct numerical simulation of the potential Euler equations with the use of the High-Order Spectral Method. The irregular waves at the initial state are characterized by the given JONSWAP frequency spectrum and the directional spreading. The simulated conditions (up to $H_s = 7$ m) correspond to the situation almost without breaking. As waves evolve, the Fourier transform in the space of the two-component wave vector and the frequency is calculated, which provides the complete information about the instant spatial and frequency power spectra and their constituent, including the wave phases.

We propose a method of spectral decomposition of the nonlinear wave fields which allows one to distinguish the free and bound waves. Based on the new method, the evolution of the dynamical kurtosis (i.e., associated with the free wave component) is obtained from the primitive water equations for the first time. It is confirmed that in the situation of a narrow-banded spectrum the total kurtosis may significantly exceed the value of zero characteristic to the Gaussian statistics (up to 0.8 in the simulated cases), exhibiting abnormally extreme sea states. However, the values of the dynamical kurtosis are remarkably more moderate (up to 0.2) and much less dependent on the increase of the significant wave height compared to the total kurtosis. In such situations the evidence of emergence of coherent wave groups in the 3D fields is presented. The effect of the high-order nonlinearity (5-wave interactions) on the value of the kurtosis is estimated on the basis of the performed simulations as insignificant in the both situations of narrow and broad angle spectra.

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