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Instability of nonlinear waves with close wavenumbers

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Evolution of bichromatic waves represents a substantial interest in fluid mechanics, oceanography and maritime engineering, as well as in other fields of physics. In this presentation, evolution of surface water waves will be considered in the context of how close the bichromatic wave modes can be in the frequency/wavenumber space before the dynamics of their interactions changes, if it does. In this regard, the topic may be relevant across various applications for nonlinear waves in dispersive media.

The study is conducted by means of the fully nonlinear one-dimensional model for gravity water waves by Chalikov & Sheinin. This approach is based on a non-stationary conformal mapping, which allows the equations of potential flow with the inclusion of a free surface to be written in a surface-following coordinate system. This transformation does not impose any restrictions on the shape of the surface, except that it has to be possible to represent this surface in terms of a Fourier series. The model accuracy and energy conservation within the evolving wave trains is very high, it is determined by the computer precision.

We show that interaction of two monochromatic waves at the water surface enters a different dynamic regime if their wavenumbers become very close. Downshifting of the initial wave energy and growth of the first mode occur in the course of evolution of the two waves, depending on wave steepness and dk/k. Behaviour of these features change if $dk/k<0.0025$: both downshifting and growth rate become independent of dk/k, and the growth rates increases by orders of magnitude.