EGU2020-8767
https://doi.org/10.5194/egusphere-egu2020-8767
EGU General Assembly 2020

Quasi-three-dimensional simulation of crescent-shaped waves

Alexander Dosaev and Yuliya Troitskaya
Institute of Applied Physics RAS, Nonlinear geophysical processes department, Nizhny Novgorod, Russian Federation (dosaev@appl.sci-nnov.ru)

Many features of nonlinear water wave dynamics can be explained within the assumption that the motion of fluid is strictly potential. At the same time, numerically solving exact equations of motion for a three-dimensional potential flow with a free surface (by means of, for example, boundary integral method) is still often considered too computationally expensive, and further simplifications are made, usually implying limitations on wave steepness. A quasi-three-dimensional model, put forward by V. P. Ruban [1], represents another approach at reducing computational cost. It is, in its essence, a two-dimensional model, formulated using conformal mapping of the flow domain, augmented by three-dimensional corrections. The model assumes narrow directional distribution of the wave field and is exact for two-dimensional waves. It was successfully applied by its author to study a nonlinear stage of of Benjamin-Feir instability and rogue waves formation.

The main aim of the present work is to explore the behaviour of the quasi-three-dimensional model outside the formal limits of its applicability. From the practical point of view, it is important that the model operates robustly even in the presence of waves propagating at large angles to the main direction (although we do not attempt to accurately describe their dynamics). We investigate linear stability of Stokes waves to three-dimensional perturbations and suggest a modification to the original model to eliminate a spurious zone of instability in the vicinity of the perpendicular direction on the perturbation wavenumber plane. We show that the quasi-three-dimensional model yields a qualitatively correct description of the instability zone generated by resonant 5-wave interactions. The values of the increment are reasonably close to those obtained from the exact equations of motion [2], despite the fact that the corresponding modes of instability consist of harmonics that are relatively far from the main direction. Resonant 5-wave interactions are known to manifest themselves in the formation of the so-called “horse-shoe” or “crescent-shaped” wave patterns, and the quasi-three-dimensional model exhibits a plausible dynamics leading to formation of crescent-shaped waves.

This research was supported by RFBR (grant No. 20-05-00322).

[1] Ruban, V. P. (2010). Conformal variables in the numerical simulations of long-crested rogue waves. *The European Physical Journal Special Topics*, *185*(1), 17-33.

[2] McLean, J. W. (1982). Instabilities of finite-amplitude water waves. *Journal of Fluid Mechanics*, *114*, 315-330.

How to cite: Dosaev, A. and Troitskaya, Y.: Quasi-three-dimensional simulation of crescent-shaped waves, EGU General Assembly 2020, Online, 4–8 May 2020, EGU2020-8767, https://doi.org/10.5194/egusphere-egu2020-8767, 2020