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A new, easily implemented representation of the Dirichlet-to-Neumann operator for the nonlinear water wave problem over arbitrary topographies

Gerassimos Athanassoulis, NTU Athens

ABSTRACT

Since the recognition by Zakharov that the free surface elevation and the trace of the velocity potential form a set of canonical variables for the nonlinear water wave problem, a lot of work has been performed in order to exploit the Hamiltonian structure for the theoretical and numerical study of the problem.

The Dirichlet-to-Neumann (DtN) operator, used to implement the internal kinematics as an essential condition, in accordance with the premises of Hamiltons principle. The main difficulty in this approach is the treatment of DtN operator.

In the case of constant depth, the functional (Volterra-Taylor) series expansion of DtN, implemented in the Fourier space has been proved an efficient tool for the numerical simulations as well as the asymptotic study of the problem. However, in the case of a general bathymetry, this approach becomes complicated, and has been implemented up to now only for a periodically varying bottom and for long waves over random topography. Luke introduced another variational principle for the nonlinear water-wave problem, free of the essential constraint of the internal kinematics. As a first application, we present a unified numerical investigation of nonlinear steady travelling waves, corresponding to a wide range of wave amplitudes and water depths.

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