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Wave kinematics of random directional seas

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The inclusion of at least the second order effects is considered necessary to obtain an accurately representation of ocean waves. While this is true for the surface elevation, very little is known concerning the velocity potential and hence the kinematics of the wave field. Here we attempt to investigate the role of second and higher order nonlinearity on the velocity. Particular emphasis is given to the effect of the wave directional spreading on nonlinear wave-wave interaction.

The second order, which represents the most obvious effect of nonlinearity in the ocean, have been computed with a perturbation method that gives the exact solution of the boundary value problem. An Higher Order Spectral Method (HOSM), which takes into account nonlinear wave dynamics and hence modulational instability processes that are regarded as being responsible for the generation of extreme waves is used to compute both water elevation and velocity potential too. Different initial random directional seas have been considered and Monte Carlo simulations have been performed to study the statistical properties of wave kinematics.

Results show that the statistical properties of the wave kinematics is significantly affected by the wave directional spreading. Departure of the tail of the probability distribution from Gaussian statistics already starts at second order and are further amplified by higher order nonlinear effects. The increase of the orbital velocity under a trough is mainly an effect of the second order contribution, the growth of the crest velocity is mainly due to a third order effect. Nevertheless the directionality of the wave field, together with the water depth, can strongly affect the relative importance of second, third and higher order contribution on the wave kinematic.