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Statistical properties of the internal solitary wave ensemble

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Internal solitary wave ensembles are often observed on the ocean shelves. The long internal baroclinic tide is generated by a barotropic tide on the shelf edges, and then transforms into the soliton-like wave packets during the nonlinear propagation to the beach. The tide is a periodic process and the solitary wave ensemble appears on the shelf usually each semi-diurnal period of 12.4 hours. This process is very sensitive to the variation of the tide characteristics and the hydrology.

We study the propagation of the soliton ensembles numerically in the framework of the spatial form of the Gardner equation (i.e., the Korteweg-de Vries equation with both, quadratic and cubic nonlinearities) assuming horizontally uniform background and applying periodic conditions in time. The water stratification and the local depth are taken similar to the conditions of the north-western Australian shelf, where the stratification admits the existence of solitons but not breathers. The numerical simulation is performed using the Gardner equation with the negative sign of the cubic nonlinearity. For the study of the statistic properties of the solitary waves we use the ensemble of 50 realizations with the same set of 13 solitary waves which are located randomly. The histograms of the wave amplitudes change as the waves travel. The histogram variations become significant after 50 km of the wave propagation. The third (skewness) and the fourth (kurtosis) statistical moments are computed versus the travel distance. It is shown that the both moments decrease by 20% when the solitary wave groups travel for about 150 km.

A similar simulation is conducted for a variable background within the framework of the variable-coefficient Gardner equation. At some location the water stratification corresponds to the positive sign of the local coefficient of the cubic nonlinearity, and then internal breathers may exist. The wave propagation in horizontally inhomogeneous hydrology leads to the occurrence of complicated patterns of solitons and breathers; in the course of the transformation they can disintegrate or form internal rogue waves. Under these conditions the statistical moments of the wave field are essentially different from case when the breather-like waves cannot occur.

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