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Interactions of coherent structures on the surface of deep water

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The interactions of coherent structures (different types of solitary wave groups) on the surface of deep water is an important nonlinear wave process, which has been studied both theoretically and experimentally[1, 2].

In the work [3], the dynamics of pairwise interactions of coherent structures (breathers) on the surface of deep water were numerically investigated in the framework of the Dyachenko-Zakharov model. Significant differences were found in the collision dynamics of breathers of the compact Dyachenko-Zakharov equation when compared to the behavior of the NLSE solitons. It was found that the maximum amplification of the wave field amplitude during the collision process of breathers can exceed the sum of their initial amplitudes. It was revealed that an important parameter determining the dynamics of pairwise collisions of breathers is the relative phase of these objects at the moment of interaction. We demonstrate that the magnitude of the energy losses of the colliding breathers to radiation depends on their relative phase and the maximum of the energy losses is observed at the same relative phase, at which the amplitude amplification maximum is observed. In addition, depending on the value of the relative phase, breathers can both can gain or lose the energy, which results in increase or decrease of their amplitude after a collision. It was found that, in contrast to the NLSE model, the spatial shifts of breathers in a more precise model can be both positive and negative.

We recover the free surface profile and the potential on the free surface of the exact breather solutions of the Dyachenko-Zakharov model using the canonical transformation. Then we use them as approximate solutions of the exact nonlinear equations for potential incompressible fluid flows. We study the role of the relative phase of the breathers in the exact nonlinear model on the dynamics of their pairwise interactions. The results of our numerical experiments in both Dyachenko-Zakharov and exact models demonstrate similar dynamics of breather interactions, which indicates that the theoretical picture of the interaction of coherent structures presented here is universal and can be observed in laboratory experiments.

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