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On the Cauchy problem for strongly nonlinear intense wave groups

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Stable long-living nonlinear groups of gravity water waves (very steep and very short envelope solitons) were first observed in numerical simulations [1, 2] and then – in laboratory conditions [3]. In [2] their interaction was shown to be almost elastic in some (but not all) situations. Therefore the Cauchy problem for localized wave groups beyond the weakly nonlinear assumption is of interest. In general, the formation of a few solitary wave groups from the initial condition may take place [4]. We have focused on the unidentified reason, why some experimental tests of solitary wave groups in [3] were not successful (while other runs with slightly different experimental parameters were successful).

In this paper we consider the initial problem, when the initial condition is taken in the form of a scaled intense envelope soliton of the nonlinear Schrodinger equation, and is simulated by means of the fully nonlinear code of potential Euler equations. The result of the long-term evolution (which is generally represented by a solitary wave group and smaller scale waves) is compared with the prediction of the weakly nonlinear theory. We show reasonable agreement between the weakly nonlinear theory and the strongly nonlinear simulations. In particular, a 10% decrease of the initial perturbation results in 20% smaller amplitude of the eventual envelope soliton. This fact explains the failure of reproduction of envelope solitons in some experimental tests in the finite-depth flume [3]. The solution of the nonlinear Schrodinger equation for finite-depth water may be transformed to the infinite-depth solution with reduced amplitude.

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