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Numerical simulation of solitary gravity waves on deep water with constant vorticity

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In theoretical studies of water waves it is common to consider the fluid motion as purely irrotational. However, wave dynamics can be strongly affected by interaction with shear currents. In nature shear is generated, for example, near the water surface due to the action of surface wind stress. An important special case is that of a linear shear flow, i.e. a flow with a uniform vorticity distribution. In such a system only potential part of velocity field is time-dependent, and usual techniques developed for potential waves can be applied to study its dynamics. It is known that long waves propagating against the current are weakly dispersive, and according to weakly nonlinear theory on deep water their evolution is described by Benjamin-Ono equation, which has soliton solutions. We investigate characteristics of solitary deep water waves on a flow with constant vorticity by numerical simulation within the framework of fully nonlinear equations of motion (Euler equations) using the method of surface-tracking conformal coordinates. We model a process of an initial pulse-like disturbance disintegration, leading to formation of one or multiple solitons. This allows us to ensure that the generated solitons are stable. Evidence is obtained that solitary waves with height above a certain threshold are unstable. We also model collision of multiple solitons, results of the simulations showing that, in contrast to Benjamin-Ono equation, solitons acquire a phase shift as a result of interaction. During the collision of solitons generation of oscillatory wave train is observed, which may indicate that solitons interact in an inelastic way and the system is nonintegrable.

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