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Head-on collision of the second mode internal solitary waves

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Second mode internal waves are widespread in offshore areas, and they frequently follow the first mode internal waves on the oceanic shelf. Large amplitude internal solitary waves (ISW) of second mode containing trapped cores associated with closed streamlines can also transport plankton and nutrients. An interaction of ISWs with trapped cores takes place in a specific manner. It motivated us to carry out a computational study of head-on collision of ISWs of second mode propagating in a laboratory-scale numerical tank using the nonhydrostatic 3D numerical model based on the Navier-Stokes equations for a continuously stratified fluid.
Three main classes of ISW of second mode propagating in the pycnocline layer of thickness h between homogeneous deep layers can be identified: (i) the weakly nonlinear waves; (ii) the stable strongly nonlinear waves with trapped cores; and (iii) the shear unstable strongly nonlinear waves (Maderich et al., 2015). Four interaction regimes for symmetric collision were separated from simulation results using this classification: (A) an almost elastic interaction of the weakly nonlinear waves; (B) a non-elastic interaction of waves with trapped cores when ISW amplitudes were close to critical non-dimensional amplitude a/h; (C) an almost elastic interaction of stable strongly nonlinear waves with trapped cores; (D) non-elastic interaction of the unstable strongly nonlinear waves. The unexpected result of simulation was that relative loss of energy due to the collision was maximal for regime B. New regime appeared when ISW of different amplitudes belonged to class (ii) collide. In result of interaction the exchange of mass between ISW occurred: the trapped core of smaller wave was entrained by core of larger ISW without mixing forming a new ISW of larger amplitude whereas in smaller ISW core of smaller wave totally substituted by fluid from larger wave. Overall, the wave characteristics induced by head-on collision agree well with the results of several available laboratory experiments.

References

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