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Nonlinear Internal Waves in Rotating Ocean

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Abstract : Effect of Earth rotation on nonlinear waves is a practically important and theoretically challenging problem of fluid mechanics and geophysics. Whereas the large-scale, geostrophic processes such as Rossby waves are a classical object of oceanic and atmospheric physics, rotation effects on mesoscale waves are not well studied. In particular, the Coriolis force can radically modify the behavior of nonlinear internal gravity waves in the ocean having spatial scales of 1-10 kilometers and time durations of few hours. In the last decade, such a non-trivial behavior was observed more than once. Similar effects are possible for magnetic sound in the ionosphere. Here we outline the main physical peculiarities in the behavior of nonlinear internal waves due to the rotation effect and present some results of our recent studies. The consideration is based on the fourth-order equation derived by one of the authors as a rotation-modified Korteweg–de Vries (rKdV) equation which includes two types of dispersion: one is responsible for the finiteness of depth as in the classical KdV equation; another is due to the Coriolis effect. This equation is, in general, non-integrable; moreover, under the conditions typical of oceanic waves (positive dispersion parameter), it does not allow solitary solutions at all. In the opposite case (negative dispersion) which is possible for, e.g., magnetic sound, solitary solutions do exist and can form complex bound states (multisoliton). Another non-trivial properties of nonlinear internal waves with rotation include, to name a few, the ‘terminal’ damping of the initial KdV soliton disappearing in a finite time due to radiation losses caused by Earth’s rotation, and eventual transformation of a KdV soliton into a wave packet (an envelope soliton). The new results to be discussed refer to the interaction of a soliton with a long background wave. It is shown, in particular, that in this case internal solitons can exist since the radiation losses are compensated by energy pumping from the background wave. Finally, the relevant oceanic observations of rotation effect on internal waves are briefly described.

Keywords : Earth rotation, internal waves, nonlinear waves, solitons
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