Abstract View

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Equatorial Solitary Waves. Part 2: Envelope Solitons

John P. Boyd

Department of Atmospheric and Oceanic Science, University of Michigan, Ann Arbor, MI 48109

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ABSTRACT

Via the method of multiple scales, it is shown that the time and space evolution of the envelope of wave packets of weakly nonlinear, strongly dispersive equatorial waves is governed by the Nonlinear Schrödinger equation. The diverse phenomena of this equation—envelope solitons, sideband instability, FPU recurrence and more—is briefly reviewed. Which of the alternatives occurs is determined largely by the relative signs of the coefficients of the dispersive and nonlinear terms in the Nonlinear Schrödinger equation which, for a given latitudinal mode, are functions of a single nondimensional parameter, the zonal wavenumber k. Gravity waves propagating toward the east form solitary waves and are subject to sideband instability only for large k. The mixed Rossby-gravity wave has solitons only in a range of intermediate k.

For waves with group velocities toward the west, the physics is much more complicated because these waves have an infinite number of second harmonic resonances and long wave/short wave resonances tucked into a finite interval of intermediate wavenumber. These two species of resonance form the topic of the two companion papers Boyd (1983a,b). One finds that for westward-propagating gravity waves, the resonances are very weak, and solitary waves occur more or less continuously within an intermediate range of wavenumber. For Rossby waves one can also state that solitons are forbidden for both large and small k, but the resonances completely dominate the intermediate range of wavenumbers so that the situation is very confused and complicated.

Together with earlier papers, this present work completes the description of the weakly nonlinear evolution of equatorial waves in a shallow water wave model.

top

Headquarters: 45 Beacon Street Boston, MA 02108-3693
DC Office: 1120 G Street, NW, Suite 800 Washington DC, 20005-3826
amsinfo@ametsoc.org Phone: 617-227-2425 Fax: 617-742-8718
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