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Evolution of Random Nonlinear Infragravity Waves in Coastal Waters

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The observed spectra of nearshore infragravity waves are typically mixed, with a discrete component (edge waves, trapped waves, propagating parallel to the coast) and a continuous one (leaky waves, that propagate from, and radiate back into, the deep ocean. See e.g., Oltman-Shay and Guza, 1987). The evolution of infragravity spectrum is driven by three general processes: 1) edge-leaky interactions, that transfer energy to the system from shorter waves; 2) energy redistribution through edge-edge and edge-leaky interactions; 3) and energy dissipation due to processes such as bottom friction.

Previous studies treated either the edge and leaky system, in isolation from the other one, and focused on phase-resolving dynamical equation. Following Whitham (1976), who derived the nonlinear edge-wave solutions for the shallow water equations, theoretical work on the nonlinear edge-edge interaction resulted in many significant extensions (e.g., Kirby et. al. 1998, Pelinovsky et. al. 2010). The interaction between standing edge waves and a normally incident wave has been investigated both within the framework of the shallow-water equation (Guza and Davis 1974) and full water wave theory (Minzoni and Whitham, 1977).

Here, we derive a general dynamical equation for the full mixed edge-leaky spectrum over a laterally uniform beach based on Zakharov's (1968, 1999) Hamiltonian formalism. The introduction of canonical variables in this formalism significantly simplifies the complicated derivation of the nonlinear interaction coefficient in the previous work (Kirby et. al. 1998, Pelinovsky et. al. 2010). The subharmonic resonance mechanism for edge-wave excitation (Guza and Davis, 1974) is retrieved from the model equation as a special case. The effects of dissipation induced by bottom friction are included using a perturbation approach. A kinetic equation for Zakharov's (1999) canonical variables can be derived, that reduces to the stochastic nonlinear mild-slope model of Agnon and Sheremet (1997) for the leaky spectrum. Ongoing work focuses on the investigation of the dynamical properties of the edge wave spectrum. Future goals include the development of numerical implementation and validation of the model.