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Laboratory modeling of edge wave generation over a plane beach by breaking waves

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Edge waves play an important role in coastal hydrodynamics: in sediment transport, in formation of coastline structure and coastal bottom topography. Investigation of physical mechanisms leading to the edge waves generation allows us to determine their effect on the characteristics of spatially periodic patterns like crescent submarine bars and cusps observed in the coastal zone.

In the present paper we investigate parametric excitation of edge wave with frequency two times less than the frequency of surface wave propagating perpendicular to the beach. Such mechanism of edge wave generation has been studied previously in a large number of papers using the assumption of non-breaking waves. This assumption was used in theoretical calculations and such conditions were created in laboratory experiments. In the natural conditions, the wave breaking is typical when edge waves are generated at sea beach. We study features of such processes in laboratory experiments.

Experiments were performed in the wave flume of the Laboratory of Continental and Coast Morphodynamics (M2C), Caen. The flume is equipment with a wave maker controlled by computer. To model a plane beach, a PVC plate is placed at small angle to the horizontal bottom. Several resistive probes were used to measure characteristics of waves: one of them was used to measure free surface displacement near the wave maker and two probes were glued on the inclined plate. These probes allowed us to measure run-up due to parametrically excited edge waves. Run-up height is determined by processing a movie shot by high-speed camera.

Sub-harmonic generation of standing edge waves is observed for definite control parameters: edge waves represent themselves a spatial mode with wavelength equal to double width of the flume; the frequency of edge wave is equal to half of surface wave frequency. Appearance of sub-harmonic mode instability is studied using probes and movie processing. The dependence of edge wave exponential growth rate index on the amplitude of surface wave is found. On the plane of parameters (amplitude – frequency) of surface wave we have found a region corresponding parametric instability leading to excitation of edge waves. It is shown that for small super criticalities, the amplitude of edge wave grows with amplitude of surface wave. For large amplitude of surface wave, wave breaking appears and parametric instability is suppressed. Such suppression of instability is caused by increasing of turbulent viscosity in near shore zone. It was shown that parametric excitation of edge wave can increase significantly (up to two times) the maximal run-up.

Theoretical model is developed to explain suppression of instability due to turbulent viscosity. This theoretical model is based on nonlinear mode amplitude equation including terms responsible for parametric forcing, frequency detuning, nonlinear detuning, linear and nonlinear edge wave damping. Dependence of coefficients on turbulent viscosity is discussed.