Resonant Scattering by Periodic Structures

by

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One of the possible mechanisms of forming offshore sandbars parallel to a coast is the wave-induced mass transport in the boundary layer near the sea bottom. For this mechanism to be effective, sufficient reflection must be present so that the waves are partially standing. We first outline a recent theory that strong reflection can be induced by the sandbars themselves, once the so-called Bragg resonance condition is met. For constant mean depth and simple harmonic waves this resonance has been studied by Davies (1982), whose theory, is however, limited to weak reflection and fails at resonance. Comparison of the strong reflection theory with Heathershaw's (1982) experiments is made. Furthermore, if the incident waves are slightly detuned or slowly modulated in time, the scattering process is found to depend critically on whether the modulational frequency lies above or below a threshold frequency. The effects of mean beach slope are also studied. In addition, it is found for periodically modulated wave groups that nonlinear effects can radiate long waves over the bars far beyond the reach of the short waves themselves. Recent experiments for narrow banded waves including periodic groups and wave packets over a very long patch of bars on a constant depth are then discussed. The theory is further modified for periodically spaced semi-circular cylinders on a constant depth. The equivalence between the cylinder system and a sinusoidal bedform is established. Finally, we discuss extensions to a seabed doubly periodic in two horizontal directions, first for a doubly sinusoidally wavy sea bed and then for a rectangular lattice of semi-spheres. Possible advantages of using these configurations as submerged breakers are pointed out.

Discussion

Kleinman: Resonance effects are based on sinusiodal bottom variations. How dependent is the resonant effect on the periodic structure of the bottom?

Mei: The theory can accomodate slight detuning, but we have not studied non-sinusoidal sandbars.

Stiassnie: What is the mechanism which encourages bar formation?

Mei: Mass transport. In the absence of breaking, due to Reynold's stress, sandbars are spaced one wavelength apart. Therefore, reflections and mass transport work together to induce some type of instability mechanism to cause sandbars.

Stiassnie: Was the bed you have used in the experiments fixed or moveable?

Mei: Fixed.

Stiassnie: Does wave breaking play a role in bar formation?

Mei: Yes, especially the breakpoint bar. But breaking is not the only mechanism. Experiments have been done by Barbara Karokiewicz for non-breaking waves on a slope. She found that sandbars form at one-half wavelength intervals.

Stiassnie: Are the disturbances travelling or fixed in space?

Mei: Sandbars can change, due to storms for example, but over a much longer time scale.

Beck: What is the effect of separation?

Mei: The amplitude of the bottom variation is small (6cm) relative to the wavelength (60 cm), so separation is not significant.

Newman: How does your analysis change if waves are obliquely incident?

Mei: With oblique waves, sandbars still form at one-half wavelength of the normal component to the beach. Details are given in Mei (1985) Journal of Fluid Mechanics.

Agnon: What is the effect of a current?

Mei: We do not know. Return currents induced by waves may be of second order and we have considered long waves induced by the modulation of short waves. These long waves can be regarded as currents.

Van Hooff: Is there a similarity between internal waves, as seen earlier in the slide of the Andeman sea, and wave propagation over sandbars? Both are governed by the Schroedinger equation.

Mei: Only mathematically is it easy to include non-linear effects. We would then get a coupled cubic Schroedinger equation.