1. INTRODUCTION

It has been observed in many field experiments that the distribution of waves approaching the shore becomes more uniform, so that the maximum wave height in the group decreases. Such a transformation of wave groups has important practical consequences, since it affects directly the value of the maximum wave height in the group. The importance of the significant wave height as a design parameter is generally recognized in coastal engineering. This demodulation effect may result from the dissipation in the bottom boundary layer, as well as from the nonlinear and dispersive effects, as shown in numerical simulations based on the Korteweg-de-Vries equation by Kit et al. (1995). The reduction in the maximum wave height with decrease of the water depth was also obtained numerically by Barnes & Peregrine (1995). We report here on systematic and accurately controlled experiments in which evolution of the well-defined wave groups is studied along the sloping bottom in a tank.

2. EXPERIMENTAL FACILITY AND PROCEDURE

Experiments are performed in a wave tank which is 18m long, 1.2m wide and filled to a mean water depth of 0.6m. A computer-operated wavemaker is located at one end of the tank. A false bottom made of thick marine plywood is installed in the tank. The effective water depth is 0.3m in the vicinity of the wavemaker. The bottom slope is 1:30 for the length of 7.5m along the tank. The last 5m of the false bottom represent a horizontal flat surface with effective depth of 0.05m. At the far end of the false bottom is located a wave energy-absorbing beach. Two sets of four wave gauges, each on its own bar, are used in this study. The first set of the gauges is of resistance type, while the second one is of the capacitance type. The distance between the two consecutive probes is 0.4m for the resistance wave gauges and about 0.3m for the capacitance probes. Each probe-supporting bar is mounted on a separate carriage which can be moved along the tank. More sensitive capacitance probes are used for measurements in the shallow water area, while resistance probes are used in the rest of the tank. Detailed measurements of instantaneous surface elevation are carried out at eight fixed measuring stations, thus covering 32 locations along the tank.

Wave groups with three different shapes are selected in this study. The equations describing the driving signal applied to the wavemaker are as following:

\[ s(t) = A_0 \sin(\Omega t) \sin(\omega t), \quad \Omega = \omega / 20 \]  
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\[ s(t) = A_0 \exp\left(-\frac{t}{5T}\right)^2 \sin(\omega t), \]
\[ -16T < t < 16T \]  
(3)

where \( T = \frac{2\pi}{\omega} \). These signals are repeated periodically. The first two driving signals produce identical wave group envelope, but their spectra differ essentially. The forcing signal (1) has a simple bimodal spectrum. The spectrum of (2) consists of a set of discrete frequencies, where 3 dominant modes can be identified. The third signal produces wave groups which are widely separated and have a discrete spectrum which requires a considerable number of modes for its accurate description. Experiments are carried out for \( T=0.7 \) s and for three values of the driving amplitude \( A_0 \), corresponding to a nearly linear, nonlinear, and strongly nonlinear wave steepnesses. In the vicinity of the wavemaker, the maximum values of the wave steepness \( a_0k_0 \) in the group are approximately 0.07, 0.14 and 0.21. Variation of the wave group velocity along the tank and modification of the wave power spectra are measured.

3. RESULTS AND DISCUSSION

Nonlinear effects are manifested in generation of both low and high frequency wave components in the spectra. The most striking effect observed in this study is the difference in the evolution of wave groups given by (1) and (2). In the vicinity of the wavemaker, both types of wave groups look practically identical. At larger distances, the wave groups generated by (1) tend to retain their identity, although nonlinear effects are clearly visible, while the wave groups excited by (2) are spread significantly. This spreading can interpreted as the demodulation effect. Certain spreading can also be observed in the detached wave groups excited using (3). For all shapes of forcing signals, the initially symmetric wave groups at higher amplitude loose their symmetry. Close examination of the numerical results by Barnes and Peregrine and by Kit et al. reveal similar behavior. Note that similar group shapes were observed in experiments and obtained numerically in deep water by solving the modified nonlinear Schrödinger equation (Lo & Mei 1985).

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Lo, E. and Mei, C.C. A numerical study of water-wave modulation based on a higher-order nonlinear Schrödinger equation. JFM 150, 395-416, 1985.

Recorded surface elevation for three amplitudes of forcing. The bottom signal is the wavemaker displacement.