

EVOLUTION OF HIGH-ORDER NONLINEAR PROPERTY USING SPATIAL DEVELOPING NONLINEAR SCHRÖDINGER EQUATION IN INTERMEDIATE WATER

Hiroaki Kashima, Port and Airport Research Institute, kashima-h2w7@p.mpat.go.jp
 Nobuhito Mori, Disaster Prevention Research Institute, Kyoto University, mori@oceanwave.jp

INTRODUCTION

In the last two decades, extreme waves have become an important topic in engineering and science. According to many studies on offshore extreme waves, the deep-water four-wave interactions can lead to a significant enhancement of extreme wave occurrence from normality. The extreme wave occurrence, its understanding and prediction in deep water become getting clear. On the other hand, there are a few studies about the extreme wave occurrence in intermediate water. The authors reported that the appropriate higher-order nonlinear correction is essential to estimate the extreme wave occurrence using the standard Boussinesq equation. Therefore, the other numerical tool such as nonlinear Schrödinger equation (NLS) will be required from the point of view of the direct extreme wave modeling in intermediate water. The purpose of this study is to investigate the evolution of the high-order nonlinear property in intermediate water using the spatial developing nonlinear Schrödinger equation (SD-NLS) for the deep-water generating extreme wave modeling

OUTLINES OF METHODS

The physical experiments were performed in a two-dimensional wave tank that is 35.0 m long, 0.6 m wide and 1.5 m deep. The JONSWAP spectra characterized by the wave steepness and peak enhancement factor were given with a piston-type wave paddle. The bottom models with the different slopes were installed at the different locations in the wave tank. The offshore water depth, h , was 0.8 m. The water surface elevations were measured by 18 gages. The 40 wave trains were extracted from about 10,000 wave data sets to guarantee the statistical sensitivity of data. The numerical simulations with the 1D-SD-NLS reported by Zeng and Trulsen (2012) were conducted. The detailed numerical conditions were same to these of the physical experiments.

RESULTS AND DISCUSSION

Figure 1 shows the effects of the wave propagating distance, l , on the evolutions of the high-order nonlinear property in intermediate water for the case of the bottom slope, θ , with 1:10. l is the distance from the wave paddle to the location at $kc h = 1.363$, k_c being the wavenumber for deep-water waves. The aftereffect of kurtosis, μ_4 , which remain even in shallow water becomes clearly significant as waves with the narrow-banded spectra propagate a longer distance in deep water. In addition, it is also found that a bottom slope has no effect on the evolution of the nonlinear property. The accurate estimation of the aftereffect of kurtosis depending on the wave developments and spectral properties is important for the deep-water generating extreme wave modeling. To check the validity of SD-NLS, Figure 2 shows the

comparison of the nonlinear property with the physical experiment and SD-NLS. The behavior of kurtosis and skewness, μ_3 , as the nonlinear interactions of free waves given by SD-NLS have a good agreement with that of the physical experiments, except for the data inside the surf zone, $kc h < [kc h]_{BP}$, because the effect of the wave breaking is not considered in SD-NLS. The detail applications of SD-NLS on the estimation of the maximum wave heights and high-order nonlinear characteristics in intermediate water will be presented at the conference.

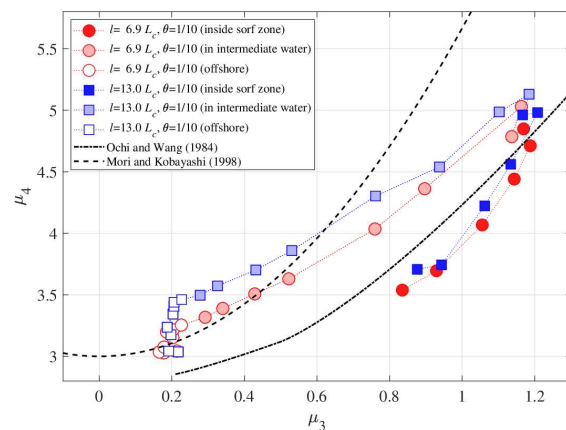


Figure 1 - Effect of spatial wave development on evolution of nonlinear property in physical experiment

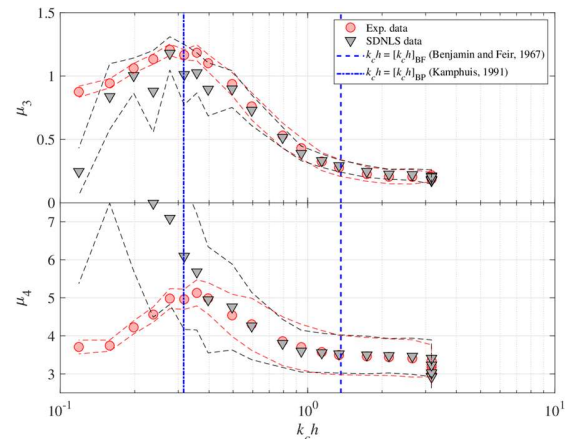


Figure 2 - Comparison of nonlinear property with physical experiment and SD-NLS equation

REFERENCES

Zeng, H. and K. Trulsen (2012): Nonlinear wave interaction and its application to the analysis of measurements of steep ocean waves, Nat. Hazards and Earth System Science, Vol.12, 631-638.