Special Program in Applied Mathematics and Applied Mechanics

Numerical modeling of the potential threat in our coastal environment-Generation of freak waves

2014 - 10 - 01 (Wed.)
15:00 - 18:00
308, Mathematics Research Center Building (ori. New Math. Bldg.)

The so-called freak waves are exceptionally large, steep, and asymmetric waves whose heights usually exceed by 2.2 times the significant wave height. These waves, described as ‘holes in the sea’ or ‘wall of waters’, have been long known to be notorious hazards to navigation vessels and marine structures. With little warning, these transient giant and steep waves can mysteriously occur from deep-water wave groups in random open seas. Many freak waves’ devastating impacts and sinister marine episodes have raised great interests in predicting their occurrence. Over the past two decades a great deal of efforts has been paid to examine the mechanisms that cause formation of freak waves. In this study, the purpose is to reproduce the potential threat in our coastal environment - generation of freak waves in a numerical wave tank. A higher-order non-hydrostatic model in a σ-coordinate system was developed. The model used an implicit finite difference scheme on a staggered grid to solve the unsteady Navier-Stokes equations with the free-surface boundary conditions simultaneously. Besides, an integral method was employed to resolve the top-layer non-hydrostatic pressure, allowing for accurately resolving free-surface wave propagation. Model accuracy was validated by linear/nonlinear progressive waves and nonlinear bi-chromatic deep-water wave groups. The model was then used to examine the two-dimensional and three-dimensional freak waves. Features of downshifting focusing location and wave asymmetry characteristics are predicted on the temporal and spatial domains of a freak wave. In the near future, an effective freak wave warming system could be developed by the present modeling framework together with sufficient field observation data.