Numerical analysis on the generation, propagation and interaction of solitary waves by a Harmonic Polynomial Cell Method

A numerical wave tank based on the Harmonic Polynomial Cell (HPC) method is created to study the generation, propagation and interaction of solitary waves. The HPC method has been proven to be of high accuracy and efficiency in modeling of water waves, wave–wave and wave–structure interaction within the context of potential flow. An important feature of the present HPC method is that the free surface and solid boundaries are immersed in a stationary Cartesian grid. Solitary waves with $\sigma$, i.e. amplitude to water depth ratio, up to 0.6 are generated by different methods. We demonstrate that the results based on the first-, third- and ninth-order method are less satisfactory than the fully-nonlinear method in generating solitary waves with $\sigma > 0.4$. Additionally, both the head-on and overtaking collision between two solitary waves are studied. In the investigation of the phase shifts after the head-on collision, our window model successfully explain the main reason why Su and Mirie (1980)’s third-order approximation of the uniform phase shifts is inconsistent with Chen and Yeh (2014)’s experimental results and Craig et al. (2006)’s fully nonlinear numerical results. For the overtaking collision of solitary waves, the collision process and the phase shifts are numerically analyzed. Our present result also confirms Craig et al. (2006)’s category of the overtaking collision.