Simulation of Nonlinear Irregular Waves by Green-Naghdi Theory

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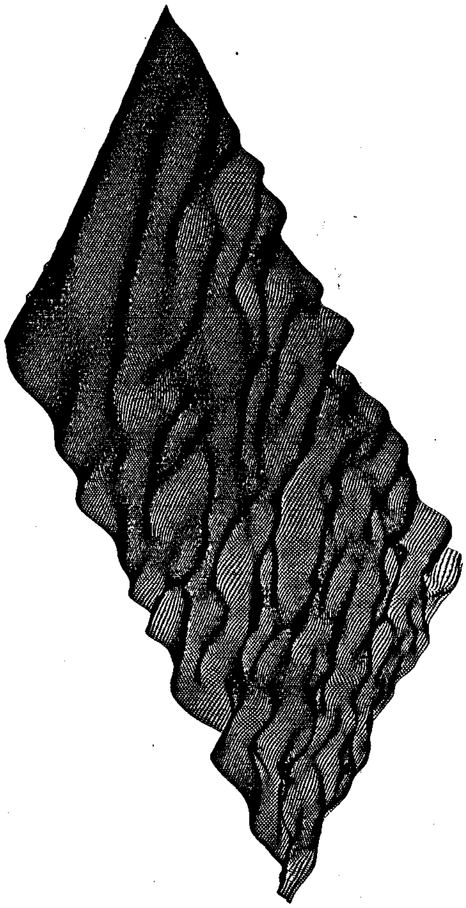
A new numerical method is developed based on Green-Naghdi theory, also refered to as fluid sheet theory, to model the propagation of nonlinear, irregular, long-crested as well as short crested waves in deep water. The 2-D level-II GN model, first published by Webster[1], is modified so that an iterative algorithm can be used to solve it. A 3-D level-II equation set suitable for an iterative algorithm is derived. The numerical method is first applied to simulate the propagation of a long-crested wave train created by an oscillating pressure disturbance acting on the free surface. In addition a numerical wave maker is developed, which is capable of generating regular and irregular waves corresponding to given wave spectra. At downstream Sommerfeld condition is employed using an average wave celerity. Because such a radiation condition is not perfect for all wave components, a sufficiently large computational domain is taken to minimize the effect of non-physical reflection. **The propagation of long-crested irregular waves is simulated by the GN model using ITTC spectrum as input.**

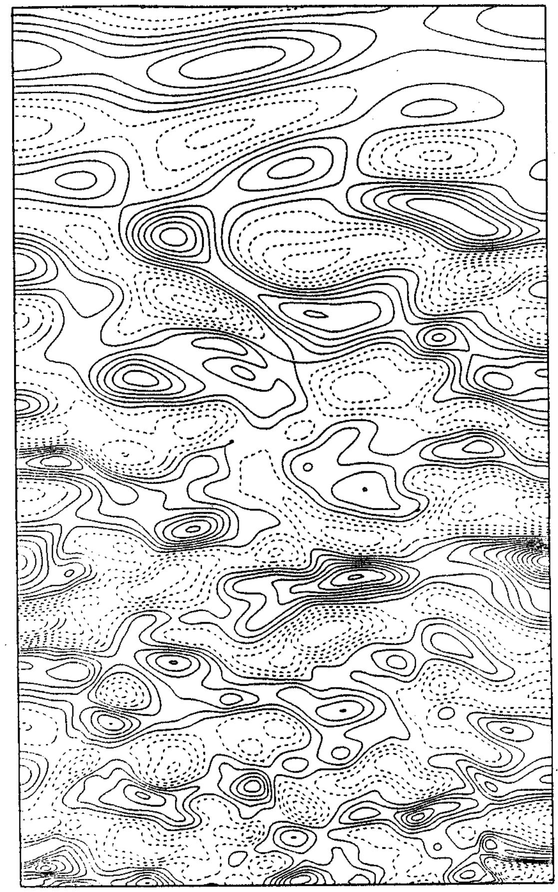
To check the capability of GN theory to simulate steep waves, we use the wave spectrum of Hurricane Camille and reproduce a time history which is used as input to the level-II GN model. The spectral properties of the simulated waves are then studied in comparison with the original input spectrum.

Parametric studies are carried out to check the effect of grid size and a representative frequency used in the GN model. It is found that long wave components are not sensitive to the selection of the representative frequency and a large representative frequency is better for short wave components. It is also found that a coarse grid system is an important reason for the energy loss in the short wave range.

A 3-D, level-II GN model is developed to simulate nonlinear multi-directional seas. A rectangular wave tank is taken and on its two sides the solid wall condition is assumed. At the downstream boundary a 3-D Sommerfeld condition is employed. A numerical wave-maker is applied to generate short-crested waves corresponding to given power directional spectra. Development of nonlinear waves created by a local pressure disturbance is calculated, and the propagation of short-crested waves is simulated by the 3-D GN model using ITTC spectrum as input.

[1] Webster,W.C. & Shields,J.J. (1990) *Applications of High- Level, Green-Naghdi Theory to Fluid Flow Problems*, IUTAM Symposium on Marine Dynamics, Brunel University, London, Elsevier Science Publisher





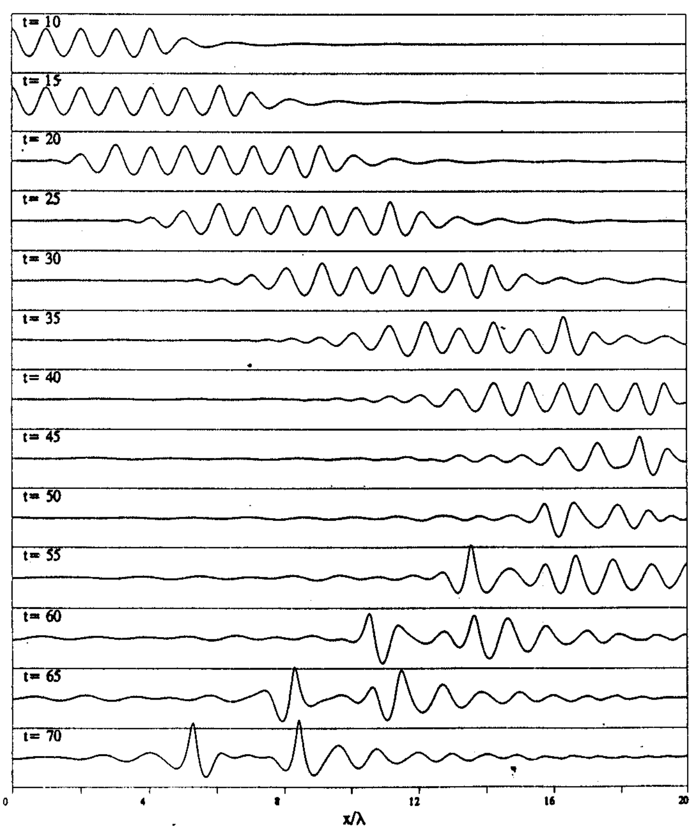


Fig. 1 : Snapshots of the wave trace at 5 period intervals

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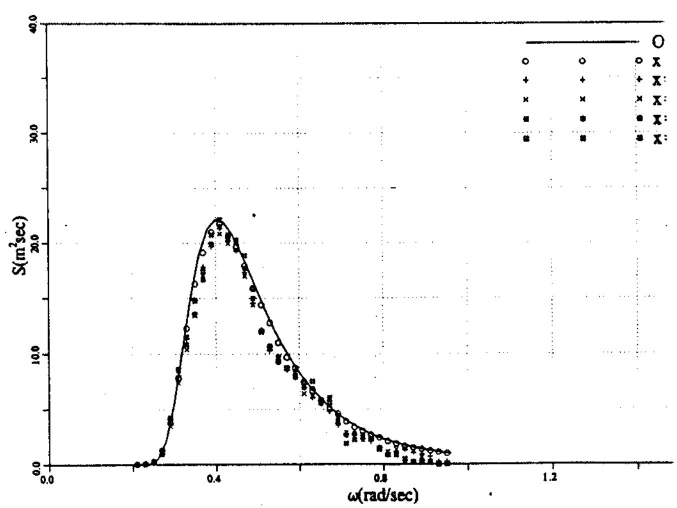

Fig.10 Original wave spectrum and those at 5 wave probes

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