Simulating the spatial evolution of a measured time series of a freak wave

Karsten Trulsen

SINTEF Applied Mathematics, P.O.Box 124 Blindern, N-0314 Oslo, Norway

karsten.trulsen@math.sintef.no

Abstract for Rogue waves 2000 workshop, Brest, 29–30 November

To explore the potential for nonlinear focusing of wave energy as an avenue to produce freak waves, it is desirable to employ a model that can follow the nonlinear evolution of a wave field in both space and time. The desired model should obey the empirical scaling laws that are observed in the field. We have earlier reported (Trulsen & Dysthe 1997) that characteristic values for steepness and bandwidth for freak ocean wave trains can be $k_c a_c \sim 0.12$ and $\Delta k/k_c \sim 0.4$, where k_c, a_c and Δk are the characteristic wavenumber, amplitude and modulation wavenumber, respectively. Therefore, we have previously argued that the modulation should be scaled as the square root of the steepness; we thus derived a modified nonlinear Schrödinger equation for this purpose (Trulsen & Dysthe 1996). Recently, we have taken the consequence of the importance of linear dispersion to an extreme, and enhanced the modified nonlinear Schrödinger equation with exact linear dispersion (Trulsen et al. 2000).

Early attempts to simulate a 2D ocean surface with the nonlinear Schrödinger equation were only partially successful due to energy leakage that broadened an initially narrow spectrum such that the model eventually violated its own bandwidth constraint. The higher-order modified nonlinear Schrödinger equation reduced the leakage such that 2D simulations became feasible. As of the new equation with exact linear dispersion, the leakage is completely eliminated. Still, numerical integration can be done as efficiently as for the conventional nonlinear Schrödinger equation through operator splitting methods.

For practical application, it may be more useful to perform space-domain simulation than time-domain simulation. Quantitative field observations are usually made measuring a time series of the surface displacement at one or a few fixed points, implying that a time-domain simulation tool would be difficult to initialize.

We cast the modified nonlinear Schrödinger equation with exact linear dispersion as a space domain simulator, and "initialize" it with a measured time series of freak waves at a point. The wave train is thus propagated up- and downstream from the probe. The consequences for neighboring marine constructions can then be discussed.

Trulsen, K. & Dysthe, K. B. 1996 A modified nonlinear Schrödinger equation for broader bandwidth gravity waves on deep water. *Wave Motion* **24**, 281–289.

Trulsen, K. & Dysthe, K. B. 1997 Freak waves — A three-dimensional wave simulation. In *Proceedings of the 21st Symposium on Naval Hydrodynamics*, pp. 550–560. National Academy Press.

Trulsen, K., Kliakhandler, I., Dysthe, K. B. & Velarde, M. G. 2000 On weakly nonlinear modulation of waves on deep water. *Phys. Fluids* **12**, 2432–2437.