Transversal crest and group modulation of extreme waves

Karsten Trulsen
Department of Mathematics, University of Oslo, Norway

Extreme waves are usually analyzed with the aid of time series measured at fixed points. This gives an impression of wave profiles in the longitudinal or propagation direction. Sometimes there may appear to be a consensus on the "typical" longitudinal profile of an extreme wave, exemplified by the New Year wave from Draupner.

Less attention has been paid to transversal patterns of extreme waves. Are they pyramidal or long-crested? Do they have the same characteristic crest-length as the rest of the wave field? Are the crests straight or curved? The answers may have serious consequences for the likelihood of being hit, and for the vulnerability of large floating structures.

Mechanically generated steep uniform waves are known to develop horseshoe patterns (Su 1982), and similar patters are also seen when a relatively strong wind blows over the sea surface (photo on page 542 in the book of Kinsman 1984). The horseshoes of Su have transversal dimensions comparable to the wavelength; and thus we may call them small horseshoes. They have limited lifetimes because they tend to break instantaneously.

There are mechanisms that favor the development of large horseshoes, i.e. modulation patterns much wider than a typical wavelength, and with longer lifetimes. One of these mechanisms, associated with envelope modulation, can be deduced from the numerical simulations of Lo & Mei (1987). There is also another mechanism associated with crest modulation. Numerical simulations suggest that these mechanisms combined act on irregular wave fields such that the most extreme waves may have long and slightly curved crests and envelopes.

References

[1] Kinsman, B. (1984). *Wind waves.* Dover.

[2] Lo, E. Y. & Mei, C. C. (1987). Slow evolution of nonlinear deep water waves in two horizontal directions: A numerical study. *Wave Motion*, **9**, 245–259.

[3] Su, M.-Y. (1982). Three-dimensional deep-water waves. Part 1. Experimental measurement of skew and symmetric wave patterns. *J. Fluid Mech.*, **124**, 73–108.