Wave Interactions and Wave Statistics in Directional Seas

The thesis is concerned with the description of extreme waves, formed when a number of wave components, travelling in different directions, focus at one point in space and time. Such waves are believed to be representative of large deep-water waves and provide a possible explanation for so-called *freak* waves. An understanding of such waves, and the more general problem of the prediction of extreme crest elevation, is of significance to the safe design of both ships and marine structures.

The statistics of maximum crest elevation have been calculated using a fully nonlinear numerical wave model in conjunction with a Spectral Response Surface method. The results show that the fully nonlinear prediction of maximum crest elevation is significantly larger than a linear or second-order theory would predict. The results also show that extreme crest elevations are most likely to occur in narrow-banded, long-crested sea-states than in broad-banded, short-crested sea-states; the differences between the two having been quantified.

A variety of time-frequency analysis techniques have been used to demonstrate that there are rapid and local changes to the wave spectrum that occur during the formation of an extreme wave. These changes shift energy to higher frequencies, alter the dispersion properties of the wave group and are directly responsible for the nonlinear increase in both crest elevation and wave front steepness. The physical mechanisms responsible for this transfer of energy have been investigated using Zakharov's Equation. This shows that the evolution of the spectrum is predominantly the result of third-order resonant interactions.

The statistics of extreme crest elevation have been calculated for a wide variety of sea-states. Those sea-states in which extreme crest elevations, and perhaps *freak* waves, are more likely to occur have been identified. These results have been explained by coupling the statistics with an understanding of the essential physics underpinning the formation of extreme waves. Furthermore, a specific instance of such an extreme event, measured on the Draupner platform on January 1 1995, has been analysed and the physical mechanisms by which it may have formed isolated.