Statistical Mechanics of the Frequency Modulation of Sea Waves

Hiroshi Tomita and Takafumi Kawamura
Ship Research Institute
Shinkawa 6-38-1, Mitaka, Tokyo 181-0004
Japan

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The cause of Rogue (Freak) waves in actual ocean area has long been investigated by many researchers, and many hypothetical mechanisms of their occurrence have been proposed from different point of views and corresponding techniques. These are classified roughly as follows.

1. Non-linear effects of water waves.
2. External influences, varying current and/or bottom topography.
3. Superposition of wave system, wave groups, multidirectional waves.

In this presentation, we pay attention to the statistical properties of wave periods and their role in the generation and annihilation of abnormal waves like Rogue waves.

Firstly, actual ocean wave data from the Sea of Japan are reexamined in detail. Several existing formulae for the probability distribution of wave periods in stochastic processes are compared with the data of 14,227 waves, which were taken in almost same sea condition. The agreement in the distribution of wave periods is not as good as in the distribution of wave heights in general. However, for this large number of wave samples, classical Weibull distribution with index 4 is found to be in good agreement. The auto correlation between successive wave periods is 0.42, which is in accordance with preceding results in this field.

Secondly, we attempt to predict the propagation characteristics of actually observed Rogue waves by assuming the linear dispersion relation for all wave frequency components in a stochastic wave field. Referring to the results of this analysis, we perform a simple numerical simulation of generating and annihilating a Rogue wave by superposing a small frequency modulated wave group. This simple model reproduces the actual feature of this phenomenon very well.