Date: April 14th

Time: 11:00 AM

Location: Maryland Hall 110

Speaker: Dr. Chin H. Wu
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Title: "Laboratory Measurements of Limiting Freak Waves on Currents"

Abstract

Freak waves, alternatively called rogue waves or giant waves, are exceptionally large, steep, and asymmetric waves whose heights usually exceed by 2.2 times the significant wave height. They have also been described as "holes in the sea" or "walls of waters". These waves have been long known to be notorious hazards to navigation vessels and marine structures. Many sinister marine episodes and their devastating impacts have prompted a great interest in freak waves. With little warning, freak waves often mysteriously occur as transient giant waves from wave groups in random coastal and open seas. While statistical methods are widely employed in examining the occurrence of such extreme sea conditions, it is still unclear whether freak waves are rare realization of a typical population or typical realization of a rare population. Likewise, it is unclear whether wave breaking (limiting wave condition) and the role of currents can affect the extreme wave statistics. Therefore, it is crucial to have a fundamental understanding of the physical mechanisms of freak wave formation and its limiting characteristics.
The results of laboratory measurements on limiting freak waves on currents are reported. Both dispersive spatial-temporal focusing and wave-current interaction are used to generate freak waves in a partial random wave field in the presence of currents. Wave group structure, e.g., spectral slope and frequency bandwidth, is found to be critical to the formation and the geometric properties of freak waves. A non-dimensional spectral bandwidth is shown to well represent wave group structure and proves to be a good indicator in determining limiting freak wave characteristics. The role of a co-existing current in the freak wave formation is recognized. Experimental results confirm that a random wave field does not prevent freak wave formation due to dispersive focusing. Strong opposing currents inducing partial wave-blocking significantly elevate the limiting steepness and asymmetry of freak waves. At the location where a freak wave occurs, the Fourier spectrum exhibits local energy transfer to high-frequency waves. The Hilbert-Huang spectrum, a time-frequency-amplitude spectrum, depicts both the temporal and spectral evolution of freak waves. A strong correlation between the magnitude of inter-wave instantaneous frequency modulation and the freak wave non-linearity (steepness) is observed. The experimental results provide an explanation to address the occurrence and characteristic of freak waves in consideration of the onset of wave breaking.