JOHNS HOPKINS
Center for Environmental
& Applied Fluid Mechanics

Weekly CEAFM Seminar: Spring 2012

Friday, April 27, 2012
11:00 a.m. – 12:00 p.m.
Gilman 50 (Marjorie M. Fisher Hall)

"NONLINEAR GROWTH OF WIND-DRIVEN SURFACE WAVES BY CRITICAL-LAYER INTERACTION"

Presented by

Dr. Sang Soo Lee

(Naval Surface Warfare Center, MD)

Abstract: A rational description of the energy transfer mechanism from wind to surface waves was given by Miles (1957). His theory describes how a resonant wind-wave interaction can be responsible for the energy transfer. This interaction occurs when surface waves induce fluctuations in the wind that are synchronized with the motion of air-water interface. The growth of a surface wave is governed by the dynamics of wave-induced fluctuations in air coupled with the air-water interface conditions. The critical layer plays an important role in this process by causing a phase jump of the fluctuation across the layer. The critical layer is a thin horizontal region surrounding the height where the mean wind velocity equals the wave phase velocity in the wind direction. Due to this phase change, the peak of pressure fluctuation above the interface becomes out of phase with the crest of a wave and the surface wave becomes unstable. A small-steepness surface wave can grow exponentially according to Miles' theory. The existence and relevance of the critical-layer dynamics of gravity waves in nature were found by Hristov, Miller & Friehe (2003). Miles' theory assumes that the initial turbulence levels are not much higher than those of wave-induced fluctuations. The theory of wave generation by turbulent wind was developed by Phillips (1957). In this presentation, we will discuss about the nonlinear growth of surface waves that can be driven by nonlinear critical-layer interaction. Nonlinear interactions between free-surface waves of the same streamwise phase velocity and wind are considered by extending the linear resonant theory of Miles. It is shown that the initial nonlinear growth of a free-surface wave could be governed by a mode-mode interaction in air, rather than in water.