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Nonlinear growth of wind-driven oblique surface waves by critical-layer interaction SANG SOO LEE, Naval Surface Warfare Center, Carderock Division — Nonlinear interaction between two (primary and secondary) free-surface waves of the same streamwise phase velocity and wind is studied by extending the linear resonant theory of Miles (1957). A nonlinear interaction occurs when the normalized amplitude of the primary 3-D wave becomes of the order of the cube of the density ratio of air to water. If the secondary wave (of smaller amplitude) is also an oblique wave, the nonlinear coupling between them generates a difference mode. Its amplitude becomes as large as the secondary wave in air, but smaller than the latter in water. In addition, the nonlinear interaction between the primary and difference modes induces a parametric growth on the secondary wave if the primary frequency is higher than the secondary frequency. The primary wave remains linear. The secondary and difference mode amplitudes are governed by integro-differential/integral equations. Numerical results show that the nonlinear growth rates become much larger than the linear growth rates. This nonlinear coupling occurs when the waves are very small. The nonlinear interaction is entirely confined to a thin critical layer (in air), and the perturbations outside the critical layer is governed by linear dynamics. It is shown that the initial nonlinear growth of a free-surface wave is governed by the mode-mode interaction in air rather than in water.

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