Nonlinear Wave Motion

John W. Miles
University of California, San Diego
Cecil H. and Ida M. Green Institute of Geophysics and Planetary Physics, 0225
La Jolla, CA 92093-0225
phone: (619) 534-2885 fax: (619) 534-5332 email: jmiles@ucsd.edu
Award: N00014-92-J-1171
http://www.onr.navy.mil/sci_tech/ocean

LONG-TERM GOALS

My research is directed toward understanding wave generation and wave motion in the ocean and in laboratory simulations thereof.

OBJECTIVES

See **LONG-TERM GOALS** above.

APPROACH

My primary approach is through mathematical models. Solutions ultimately are developed in both analytical and numerical form, but the goal is to obtain analytical results that inform phenomenological models for the prediction of physical events.

WORK COMPLETED

[1] Miles, J. 1998: A note on the Burgers-Rott vortex with a free surface, *ZAMP*, **48**, 162-165.

[2] Miles, J. and Ierley, G. 1998: Surface-wave generation by gusty wind, *J. Fluid Mech.*, **357**, 21-28.

[3] Miles, J. and Chamberlain, P. 1998: Topographical scattering of gravity waves, *J. Fluid Mech.*, **361**, 175-188.

[4] Miles, J. and Henderson, D. 1998: A note on interior vs boundary-layer damping of surface waves in a circular cylinder, *J. Fluid Mech.*, **364**, 319-323.

[5] Miles, J. (in press): The quasi-laminar model for wind-to-wave energy transfer. Proceedings of the IMA Conference: *Wind-Over-Wave Couplings: Perspectives and Prospects.*

[6] Miles, J. (in press): On gravity-wave scattering by non-secular changes in depth, *J. Fluid Mech.*

[7] Miles, J. (sub judice): A note on surface waves with a fixed contact line, *J. Fluid Mech.*

RESULTS

[1] extends Rott's (1958) solution of the 'bathtub vortex' problem, which neglects the depression of the free surface, by allowing for a mildly sloping surface. Simple analytical results are obtained for depressions of up to half the ambient depth.

[2] and [5] concern surface-wave generation by wind. [2] concerns the effects of gustiness on this energy transfer, developing the models of Janssen (1986) and, especially, Nikolayeva & Tsimring (1986). Gustiness smooths out the critical layer in the quasi-laminar model and typically increases the energy transfer. Nikolayeva & Tsimring had predicted an order-of-magnitude increase in this energy transfer, but this prediction appears to be erroneous, and [2] predicts an increase of 10-30% over most of the wave spectrum. [5] is an invited review paper dealing with my 1957 quasi-laminar model and its descendents.

[3] and [6] deal with gravity-wave propagation and scattering in water of variable depth. [3] establishes a hierarchy of equations, starting with the classical Helmholtz equation and comprising the well known mild-slope equation and Chamberlain & Porter's 'modified mild-slope equation', through an operational expansion of the underlying partial differential equations. Approximate solutions are obtained through a 'quasi-geometrical-optics' approximation, which extends the conventional geometrical-optics (ray-theory) approximation by incorporating reflection. [6] attacks the topographical-scattering problem through a functional expansion in the departure of the depth from its flat-bottom mean.

[4] deals with the calculation of interior damping of surface waves in laboratory experiments through an energy-dissipation balance and is aimed at improving our understanding of viscous and capillary-hysteresis damping of waves. The precise calculation and measurement of viscous damping is essential for the corresponding measurement of capillary hysteresis (for which our present knowledge is inadequate for theoretical calculation). Capillary hysteresis is negligible for full-scale ships but important for laboratory-scale models.

[7] extends Luke's variational formulation of the gravity-wave problem to capillary-gravity waves with a fixed contact line through the incorporation of the contact-line constraint and corresponding Lagrange multiplier.

IMPACT/APPLICATIONS

I expect that the results of [2] ultimately could be included in semi-empirical models, such as that of the WAM group, for the prediction of wind-generated waves. Perhaps more importantly, they should contribute to our understanding of air-sea interaction. The results of [3] and [6] are directly applicable to coastal engineering and naval operational problems.

TRANSITIONS

RELATED PROJECTS

PUBLICATIONS

See **WORK COMPLETED**.