PHYSICAL MATHEMATICS SEMINAR

ASYMPTOTIC ANALYSIS OF STRONGLY NONLINEAR CONVECTION IN THE OCEAN SURFACE MIXED LAYER

GREGORY P. CHINI
Department of Mechanical Engineering
University of New Hampshire, Durham

ABSTRACT:

Transport and mixing within the ocean surface boundary layer is dominated by episodic convective events. In this investigation, multiscale asymptotic analysis is used to capture the nonlinear structure and dynamics of two canonical convective flows: thermally-driven Rayleigh–Bénard convection (RBC) and wind- and wave-driven Langmuir circulation (LC). We obtain a semi-analytical description of strongly nonlinear convective states arising in both LC and RBC. In marked contrast with weakly nonlinear convection analyses, the asymptotic solutions obtained here exhibit flow features found in turbulent convection including the complete re-distribution of the basic-state temperature (or, for LC, downwind velocity) field. Comparisons with full pseudospectral numerical simulations confirm the accuracy of the asymptotic results. We then explore the Craik–Leibovich (CL) equations, governing LC, in the physically-relevant large Re_s limit, where the Reynolds number Re_s is based on the Stokes drift velocity of the surface waves and on the depth of the mixed layer. For $Re_s >> 1$, the CL vortex force dominates the flow physics, and vortices aligned with the wind direction are preferred. We leverage this limit to derive a reduced set of PDEs governing quasi-3D "Langmuir turbulence," and show that the reduced description economically captures the key 3D instabilities. The derivation of this reduced model is a first step in an effort to investigate the interaction of mesoscale ocean eddies with mixed-layer turbulence.

TUESDAY, OCTOBER 30, 2007
2:30 PM
Building 2, Room 105

Refreshments at 3:30 PM in Building 2, Room 349
(Applied Math Common Room)

Massachusetts Institute of Technology
Department of Mathematics
Cambridge, MA 02139