THE FLUIDS, THERMAL AND CHEMICAL PROCESSES GROUP
OF
THE DIVISION OF ENGINEERING
AND
CENTER FOR FLUID MECHANICS

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A Nonlinear Evolution of the Rayleigh-Taylor Unstable Fluid Interface

The Rayleigh-Taylor instability (RTI) develops at the interface between two fluids, when a light fluid accelerates a heavy fluid. The turbulent mixing produced by the instabilities is of extreme importance in inertial confinement fusion, astrophysics, and many other applications. To obtain a reliable description of the mixing process, the evolution of the large-scale coherent structure, the dynamics of small-scale structures, and the cascades of energy should be understood. The dynamics of RTI is governed by a system of conservation laws, which are nonlinear partial differential equations with the initial conditions and the boundary conditions at the fluid interface. Singular aspects of the interface evolution cause theoretical difficulties and preclude elementary methods of solution.

We suggest a new theoretical approach to the problem. It is based on group theory, applies the separation of scales in the governing equations, and accounts for the non-local properties of the flow that has singularities. Asymptotic solutions describing the large-scale coherent dynamics are found. The analysis yields a non-trivial dependence of the interface evolution on the density ratio and the acceleration history, and determines the key properties of the spatial RT flow. Our results show that a balance between the inverse and direct cascades is required to keep an isotropy of the coherent structures. The theory explains existing observations, predicts new universal properties of the interface dynamics, and identifies sensitive diagnostic parameters for future observation.

Tuesday – March 16, 2004
Barus & Holley, Room 190
4:00pm