Mon4.3 Abarzhi et al.

Nonlinear evolution of the Rayleigh-Taylor and Richtmyer-Meshkov unstable fluid interface

S.I. Abarzhi[1], M. Herrmann[1], K. Nishihara[2] & J. Glimm[3]

1. Center for Turbulence Research,
Stanford, USA
snezha@summer8.stanford.edu

2. Institute of Laser Engineering,
Osaka University, Japan

3. Department of Applied Mathematics,
SUNY Stony Brook, USA

The Rayleigh-Taylor (Richtmyer-Meshkov) instability develops at the interface between two fluids, when a light fluid accelerates a heavy fluid. The instability dynamics 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 report the theoretical and numerical results, which describe the nonlinear dynamics of the RT/RM large-scale coherent structure.

Our theoretical approach to the problem is based on group theory. We apply the separation of scales in the governing equations, and account for the non-local properties of the flow that has singularities. Nonlinear asymptotic solutions are found to describe the large-scale coherent dynamics of bubbles and spikes in the Rayleigh-Taylor and Richtmyer-Meshkov instabilities for fluids with a finite density ratio in general three-dimensional case. The theory yields a non-trivial dependence of the bubble velocity and curvature on the density ratio, and reveals an important qualitative distinction between the dynamics of the Rayleigh-Taylor and Richtmyer-Meshkov bubbles. Our analysis determines the key properties of the spatial RT and RM flows, predicts new universal properties of the interface dynamics, and finds the invariants of flow in both RTI and RMI. Our numerical simulations track the interface dynamics explicitly. The theoretical and numerical results are in a very good agreement with each other and with existing observations. New sensitive diagnostic parameters are identified for experiments.