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Abstracts of Papers to Appear

A Critical Analysis of Rayleigh–Taylor Growth Rates. J. Glimm,*,† J. W. Grove,‡ X. L. Li,* W. Oh,* and D. H. Sharp.§ *Department of Applied Mathematics and Statistics, University at Stony Brook, Stony Brook, New York 11794-3600; †Center for Data Intensive Computing, Brookhaven National Laboratory, Upton, New York 11793-6000; ‡Hydrodynamics Methods Group, Applied Physics Division, Los Alamos National Laboratory, Los Alamos, New Mexico 87545; and §Complex Systems Group, Theoretical Division, Los Alamos National Laboratory, Los Alamos, New Mexico 87545.

Recent simulations of Rayleigh–Taylor instability growth rates display considerable spread. We provide evidence that differences in numerical dissipation effects (mass diffusion and viscosity) due to algorithmic differences and differences in simulation duration are the dominant factors that produce such different results. Within the simulation size and durations explored here, we provide evidence that the principal discrepancies are due to numerical dispersion through comparison of simulations using different algorithms. We present new 3D front tracking simulations that show tentative agreement with the range of reported experimental values. We begin an exploration of new physical length scales that may characterize a transition to a new Rayleigh–Taylor mixing regime.

Direct Numerical Simulations of Fluid–Solid Systems Using Arbitrary–Lagrangian–Eulerian Technique. Howard H. Hu, N. A. Patankar,* and M. Y. Zhu. Department of Mechanical Engineering and Applied Mechanics, University of Pennsylvania, Philadelphia, Pennsylvania 19104-6315; *Department of Aerospace Engineering and Mechanics, University of Minnesota, Minneapolis, Minnesota 55455.

Since its initial publication, the numerical method developed for direct simulations of fluid–solid systems using the Arbitrary–Lagrangian–Eulerian (ALE) technique has undergone continuous modification. We present the most up-to-date implementation of the method and the results of several benchmark test problems.

A Numerical Method for Two-Phase Flow Consisting of Separate Compressible and Incompressible Regions. Rachel Caiden,* Ronald P. Fedkiw,† and Chris Anderson.* *Department of Mathematics, University of California Los Angeles, Los Angeles, California 90095; †Computer Science Department, Stanford University, Stanford, California 94305.

We propose a numerical method for modeling two-phase flow consisting of separate compressible and incompressible regions. This is of interest, for example, when the combustion of fuel droplets or the shock induced mixing of liquids is numerically modeled. We use the level set method to track the interface between the compressible and incompressible regions, as well as the Ghost Fluid Method (GFM) to create accurate discretizations across the interface. The GFM is particularly effective here since the equations differ in both number and type across the interface. The numerical method is presented in two spatial dimensions with numerical examples in both one and two spatial dimensions, while three-dimensional extensions are straightforward.

Level Set Methods: An Overview and Some Recent Results. Stanley Osher* and Ronald P. Fedkiw.† *Department of Mathematics, University of California Los Angeles, Los Angeles, California 90095; and †Computer Science Department, Stanford University, Stanford, California 94305.

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The level set method was devised by Osher and Sethian as a simple and versatile method for computing and analyzing the motion of an interface Γ in two or three dimensions. Γ bounds a (possibly multiply connected) region Ω. The goal is to compute and analyze the subsequent motion of Γ under a velocity field $\vec{v}$. This velocity can depend on position, time, the geometry of the interface and the external physics. The interface is captured for later time as the zero level set of a smooth (at least Lipschitz continuous) function $\varphi(\vec{x}, t)$; i.e., $\Gamma(t) = \{\vec{x} \mid \varphi(\vec{x}, t) = 0\}$. φ is positive inside Ω, negative outside Ω, and zero on $\Gamma(t)$. Topological merging and breaking are well defined and easily performed. In this review article we discuss recent variants and extensions, including the motion of curves in three dimensions, the Dynamic Surface Extension method, fast methods for steady state problems, diffusion generated motion, and the variational level set approach. We also give a user's guide to the level set dictionary and technology, couple the method to a wide variety of problems involving external physics, such as compressible and incompressible (possibly reacting) flow, Stefan problems, kinetic crystal growth, epitaxial growth of thin films, vortex dominated flows, and extensions to multiphase motion. We conclude with a discussion of applications to computer vision and image processing.

Evolution, Implementation, and Application of Level Set and Fast Marching Methods for Advancing Fronts. J. A. Sethian. Department of Mathematics, University of California, Berkeley, California 94720.

A variety of numerical techniques are available for tracking moving interfaces. In this review, we concentrate on techniques that result from the link between the partial differential equations that describe moving interfaces and numerical schemes designed for approximating the solutions to hyperbolic conservation laws. This link gives rise to computational techniques for tracking moving interfaces in two and three space dimensions under complex speed laws. We discuss the evolution of these techniques, the fundamental numerical approximations involved, implementation details, and applications. In particular, we review some work on three aspects of materials sciences: semiconductor process simulations, seismic processing, and optimal structural topology design.